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DEC 1947

Vol. XXXI JULY-AUGUST-SEPTEMBER, 1947 No. 1

THE PHILIPPINE AGRICULTURIST

UNIVERSITY OF THE PHILIPPINES PUBLICATIONS: SERIES A

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Published by
THE COLLEGE OF AGRICULTURE
UNIVERSITY OF THE PHILIPPINES

The Philippine Agriculturist

(University of the Philippines Publications: Series A)

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THE PHILIPPINE AGRICULTURIST is published quarterly, beginning with Volume 31, by the College of Agriculture, University of the Philippines, Los Baños, Laguna. The subscription price is ₱6.00 a year in the Philippines and $4.00 (U. S. currency) elsewhere; the price of single copies, ₱2.00 in the Philippines and $1.00 (U. S. currency) elsewhere.

Business correspondence should be addressed to the Business Manager, THE PHILIPPINE AGRICULTURIST, College, Laguna, Philippines. All remittances should be made payable to THE PHILIPPINE AGRICULTURIST.

Communications for the editor should be addressed to the Editor, THE PHILIPPINE AGRICULTURIST, College, Laguna, Philippines.

Publications sent in exchange for THE PHILIPPINE AGRICULTURIST should be addressed: Library, College of Agriculture, College, Laguna, Philippines.

Entered at the Post Office at College, Laguna, Philippines, as second-class mail matter.

A BIOLOGICAL STUDY OF EMPOASCA FLAVESCENS FABRICIUS (CICADELLIDAE, HOMOPTERA) [1]

S. M. CENDAÑA AND CLARE R. BALTAZAR [2]
Of the Department of Entomology

WITH THREE TEXT FIGURES

Empoasca flavescens Fabricius attacks several cultivated crops when it is abundant and can become a very serious pest of those crops. During the Japanese occupation, when there was a general campaign for cotton growing in different parts of Luzon, *Empoasca flavescens*, the cotton leafhopper, otherwise known as the green fly of tea, was so abundant that it became one of the main causes of the failure of the cotton culture. The insect causes serious hopperburns by sucking the juice of the leaves of the affected plants, and young plants succumb readily to its attack. At times it seriously affects the eggplant and okra.

Woodworth (1921, 1922), Merino (1936), and other authors have reported that *Empoasca flavescens* damages cotton and various solanaceous crops in the Philippines. Dammerman (1929, p. 238) stated that the species is almost world-wide in distribution and is a serious pest in India, where it is known as the "green fly of tea." Silvestri (1934), citing Oshanin's 1912 paper, said that the species is distributed in all regions of the world, except Australia, but that after Tulgren fixed the specific characters of *Empoasca flavescens*, these distributional records may have to undergo revision.

Speaking of the same species, Essig (1926) mentioned its occurrence throughout the eastern United States and some western states, like Colorado, New Mexico, Arizona, and California.

Shroff (1912) also reported the distribution of the pest in India and Burma. In the same article he gave a brief description of the cotton leafhopper together with a short account of its life history and some treatment for its control but gave no data concerning the developmental periods of the pest.

In the Philippines, Otanes and Butac (1935) reported on the pest's becoming very numerous towards the end of the rainy season and causing

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[1] Experiment Station contribution No. 1455. Portions of the data used here were included in a thesis presented by the junior author for graduation, 1947, with the degree of Bachelor of Science in Agriculture.

[2] The authors wish to aknowledge their indebtedness to Dean L. B. Uichanco for valuable suggestions and the use of his library.

serious harm to the cotton crop. Otanes (1946) considers *Empoasca flavescens* a destructive leafhopper of the eggplant, whose nature and symptoms of attack are like those of aphids. He recommends for control measures those applied to plant lice.

The present work was undertaken in the entomology laboratory of the College of Agriculture and in the fields in the vicinity of the College campus to study (*a*) the life history of the pest, (*b*) its host plants, and (*c*) control.

MATERIALS AND METHODS

Adult hoppers were caught in the field and made to lay eggs in potted cotton seedlings. Bottles with both ends cut and covered with a piece of fine gauze at the top end served as breeding cages. Cotton leaf cuttings which were made to root in vials were tried for egg-laying, but no success was obtained with this method. However, these leaves were utilized in rearing individual nymphs in the life-history studies.

For anatomical studies, samples of each nymphal instar were preserved in alcohol. Adults were macerated in 5 per cent caustic soda, washed, cleared in alcohol and xylene, and mounted in balsam.

LIFE HISTORY

After hatching from the egg, *Empoasca flavescens* passes through five nymphal instars, the fifth molt being the transition to the adult stage.

The incubation period of eggs that developed into male leafhoppers ranged from 5 to 9 days, with a mean of 6.6 days. Most of the eggs (75.9 per cent) hatched 6 or 7 days after they were laid. The incubation period of eggs that developed into female leafhoppers ranged from 5 to 8 days, with a mean of 6.8 days, most of the eggs (80.8 per cent) hatching 6 or 7 days after being laid. There is no significant difference in the incubation period of eggs that developed into male and female leafhoppers as the analysis in table 1 shows.

The eggs are laid in the veins of the leaf, the petiole, and the tender portion of the stems. (Only one egg, which was laid parallel to the vein with the bigger end inserted first, was found in each egg puncture. On the vein where the eggs were laid, there was slight swelling of the tissues but on the stem and petiole, no swelling was observed).

The eggs hatch usually in the morning and late in the afternoon. The young nymph pushes its way out of the tissues of the plant and in so doing the egg shell is dragged out by the hatching nymph. (Plants from which nymphs hatched out were seen with the white egg shell protruding from the point of exit of the nymph. When the tissues were dissected, the nymph was seen to have come out from the anterior end of the egg. It took about

20 minutes for the nymph to come out of the plant tissues. It migrated to younger leaves and started feeding a few minutes later.)

The first stadium ranged from 1 to 2 days for both sexes, those hatching one day after they were laid being almost as numerous (55 per cent in males and 52 per cent in females) as those hatching two days after oviposition (43 per cent in males and 48 per cent in females). The mean was 1.45 days for males and 1.48 days for female leafhoppers.

The second stadium ranged also from 1 to 2 days in both sexes, with more of the nymphs (79 per cent in the males and 63 per cent in the females) undergoing the second molt one day after the first molt. The mean was 1.20 days for the males and 1.37 for the females.

The third stadium ranged from 1 to 3 days in the males and 1 to 2 days in the females, with most of the nymphs in both sexes (71 per cent of the males and 67 per cent of the females) undergoing the third molt one day after the second molt. The average third stadium was 1.33 days for both sexes.

The fourth stadium ranged from 1 to 3 days in the males and from 1 to 4 days in the females, with most of the nymphs in both sexes (90 per cent of the males and 86 per cent of the females) undergoing the fourth molt one or two days after the third molt. The mean for the fourth stadium was 1.55 days in the males and 1.75 days in the females.

The fifth or last nymphal stadium of both sexes ranged from 1 to 4 days, with most of the nymphs (56.9 per cent in the males and 53.7 per cent in the females) undergoing the fifth molt two days after the fourth molt. The mean for the fourth stadium was 2.03 days for the male and 2.06 days for the female.

The male nymphs developed into adults in 5 to 10 days after hatching, with most of them (55 per cent) completing the development in seven days. The female nymphs developed into adults in 6 to 10 days after hatching; seven days after hatching, only 33 per cent of them had completed development. The mean developmental period for the male nymphs was 7.55 days; for the female, 8 days. The analysis presented in table 2 shows this difference to be significant.

The total developmental period (from egg-laying to emergence as adults) for the males ranged from 11 to 17 days, with most of them (74 per cent) completing in 13 to 15 days; the average was 14.2 days. In the females, the total developmental period was from 12 to 18 days, with most of them (77 per cent) completing in 14 to 16 days. The average was 14.8 days. This difference is significant, as shown in the analysis presented in table 3.

The nymphs molt at any time of the day but usually toward noon time. They attach themselves to the leaf with their claws and come out through a dorso-medial crack on the head. Soon after molting they start feeding. The nymphs feed on the nether surface of the leaves where the veins branch. When disturbed they move sideways. The older nymphs may jump when disturbed.

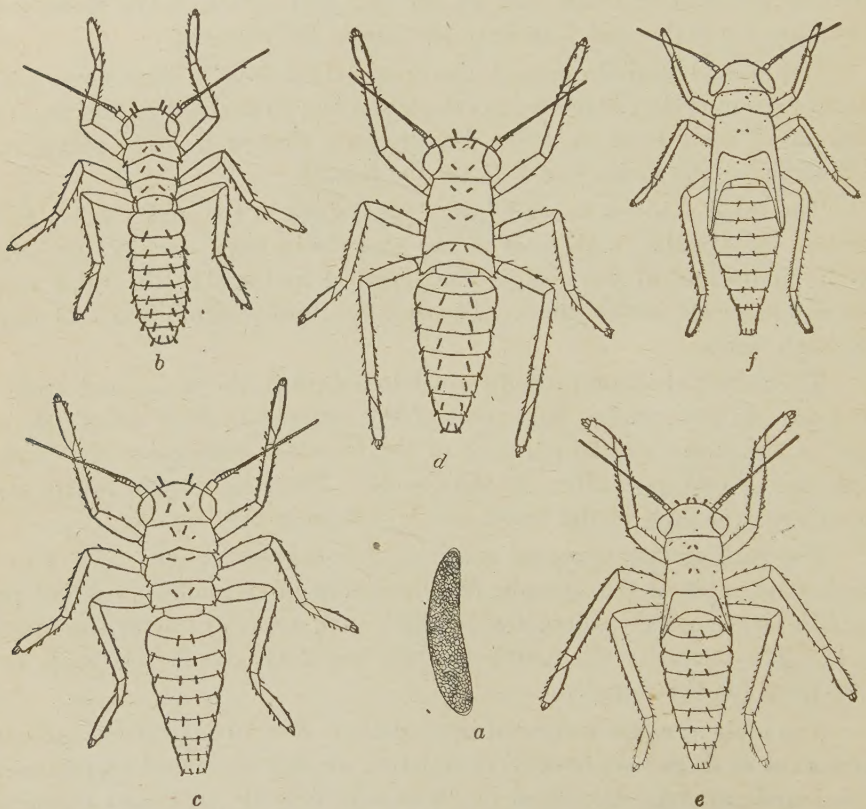

Fig. 1.—(*a*) Egg, side view (× 39); (*b*) first-instar nymph, dorsal aspect (× 35); (*c*) second-instar nymph, dorsal aspect (× 34); (*d*) third-instar nymph, dorsal aspect (× 26); (*e*) fourth-instar nymph, dorsal aspect (× 19); (*f*) fifth-instar nymph, dorsal aspect (× 16).

The description of the different stages is as follows:

Egg. [fig. 1 (*a*)]. Length 0.55 mm., diameter 0.15 mm. Elongated, slightly curved, posterior pole conspicuously larger than the anterior pole; both ends smoothly rounded; opaque, bluish white; shell irregularly reticulate, surfaces smooth. (Description based on egg dissected from mother).

First-instar nymph. [fig. 1 (*b*)]. Pale greenish yellow when newly hatched, later turning yellowish green.

Body elongate-oval in dorsal outline; head, prothorax, and second to sixth abdominal segments subequal in width, beset with subcapitate setae arranged linearly in four rows along meson.

Head seen from above subpentagonal, from below subtriangular; rounded in front, about half as long as wide, widest at eyes, beset with few round-tipped setae. Eyes subelliptical, purplish black, about half as long as head. Antenna setaceous, length about twice the width of head; scape subcylindrical, about as long as wide; pedicel subcylindrical, subequal in length and width to scape. Flagellum constricted at base, very many, jointed; first joint largest, subtriangular, about three-fifths as wide as long, length subequal to width of pedicel; second and third joints subequal, width about two-thirds that of first joint; fourth and fifth joints subequal slightly narrower than third; succeeding joints subequal in length, gradually narrowing to the tip. A pair submarginal clypeal setae present; labium three-jointed, tip of labium reaching beyond hind coxae.

Thorax seen from above about twice as long as head, widest at prothorax; metanotum slightly narrower than mesonotum; pro-, meso-, and metanota subequal in length, each with a pair of lateral and submedial subcapitate setae. Mesonotum rectangular, metanotum slightly narrowed posteriorly. Wing pads absent. Legs subequal in size, sparsely beset with fine hairs, except at femur, which is naked. Coxa and trochanter subglobular and subequal; femur subcylindrical, as long as tibia; tibia subcylindrical, about three-fifths as wide as femur; tarsus two-jointed, first joint narrower than tibia, second segment as wide as tibia and about two and one-half times as long as first segment; claws of equal length.

Abdomen subovate, apparently nine-segmented. First abdominal tergite subequal in length to other tergites, two-thirds as long and about three-fifths as wide as second tergite; second tergite almost as wide and one and one-half times as long as third; third to sixth tergites subequal in length and width, abdomen tapering posteriorly from the seventh tergite; last abdominal segment subconical, about three-fourths as long as wide; four rows of subcapitate setae on each abdominal tergite, confluent with those on thoracic segments with which they form four dorsal longitudinal rows.

An apparently average-sized first-instar nymph measured as follows: Length of body (exclusive of appendages) 0.85 mm., greatest width (at prothorax) 0.20 mm.; head 0.15 mm. in length and 0.25 mm. in width; antenna 0.50 mm. in length and 0.25 mm. in width; proboscis 0.25 mm. long and 0.05 mm. wide; length of fore leg 0.55 mm., of middle leg 0.60 mm., and of hind leg 0.75 mm.; length of abdomen 0.40 mm.

Second-instar nymph. [fig. 1 (*c*)]. General color yellowish green.

Exclusive of size, the second-instar nymph is similar in appearance to the first instar, except for the following features: metanotum rectangular, not narrowed posteriorly; first abdominal tergite half as wide as second abdominal tergite (three-fifths as wide as second tergite in first instar), labium about one-third as wide as thorax and less than half as long as abdomen.

Measurements of an apparently average-sized nymph were as follows: Length of body (exclusive of appendages) 1.05 mm., width (at prothorax) 0.30 mm.; head 0.15 mm. in length and 0.30 mm. in width; antenna 0.60 mm. long and 0.03 mm. wide; proboscis 0.25 mm. long; length of fore leg 0.75 mm., of middle leg 0.80 mm., and of hind leg 0.90 mm.; length of abdomen 0.55 mm.

Third-instar nymph. [fig. 1 (*d*)]. General color pale yellowish green.

Body elongate-oval from above, rounded anteriorly, widest at abdomen, sparsely beset with round-tipped hairs, rows arranged as in earlier instars.

Head subglobular in dorsal outline, about three-fifths as long as wide, rounded anteriorly; eyes brownish-black, bulging out prominently on the sides of head; labium extending to hind coxae, less than half as long as abdomen.

Thorax seen from above subrectangular, about three-fifths as wide as long. Pronotum subrectangular, slightly narrowed anteriorly, broadly sinuate posteriorly. Mesonotum slightly wider posteriorly than anteriorly, sides slightly produced posteriorly to form rudiments of fore wing pads, submarginal seta located before apex. Metanotum similar in appearance to mesonotum but about half as long, hind wing pads not extending posteriorly beyond anterior margin of second abdominal segment.

Abdomen ovate in dorsal outline, widest at third, fourth, and fifth segments. Ninth abdominal segment bluntly conical. Rudiments of gonapophyses appearing as a pair of approximated conical stubby outgrowths on ventral surface of ninth segment in the male as paired medially approximated conical outgrowths on the eighth and ninth segments in the female; gonapophyses much shorter than abdomen in both sexes.

An apparently average-sized third-instar nymph had the following measurements: Length of body 1.45 mm., width 0.45 mm.; length of head 0.20 mm., width 0.45 mm.; length of antenna 0.70 mm., width 0.03 mm.; length of fore leg 1.20 mm., of middle leg 1.30 mm., of hind leg 1.50 mm.

Fourth-instar nymph. [fig. 1(*e*)]. General color pale yellowish green.

Similar in appearance to third instar except as follows: wing pads much longer than wide, fore wing pads overlapping and posteriorly sub-

coextensive with hind wing pads; hind wing pads reaching to third abdominal segment but not beyond proximal third of abdomen. Last abdominal segment subconical, not much longer than preceding segment. Gonapophyses coextensive with tip of abdomen.

An apparently average-sized fourth-instar nymph measured as follows: Length of body 1.75 mm., width 0.45 mm.; length of head 0.20 mm., width 0.50 mm.; length of antenna 0.80 mm., width 0.03 mm.; length of fore leg 1.00 mm., of middle leg 1.20 mm., of hind leg 1.45 mm.

Fifth-instar nymph. [fig. 1 (*f*)]. General color pale green on head and abdomen, greenish yellow at thorax.

Body from above oblong, widest at midabdomen. Head over twice as wide as long, less than half as long as thorax, rounded anteriorly; eyes extending posteriorly beyond anterior limits of pronotum; pronotum subrectangular, slightly narrowed anteriorly, one-third as long as wide; meso- and metanota similar in shape; fore wing pads longer than width of thorax, posteriorly coextensive with hind wing pads and reaching to anterior margin of fifth segment or to approximately one-half length of abdomen; setae on head and on pro-, meso- and metanota less prominent than in younger instars. Legs conspicuously armed with rows of spines.

Abdomen elongately conical, last abdominal segment tubular and longer than preceding segment.

An apparently average-sized fifth-instar nymph measured as follows: Length of body 2.20 mm., width 0.60 mm.; length of head 0.20 mm., width 0.50 mm.; length of antenna 0.90 mm., width 0.03 mm.; length of fore leg 1.20 mm., of middle leg 1.30 mm., of hind leg 1.80 mm.

A separation key for the different nymphal instars is given below:

Key for separation of nymphal instars

1. Wing pads absent, no externally visible gonapophyses, last abdominal tergite much wider than long 2

   Wing pads present, with rudiments of gonapophyses, last abdominal tergite as long as wide, or longer 3

2. Less than 1 mm. in length, labium more than half as long as abdomen, thorax narrower posteriorly than anteriorly ..... INSTAR I

   At least 1 mm. long, labium one half as long as abdomen or less, metanotum at least as wide as pronotum ..... INSTAR II

3. Wing pads rudimentary, about as long as wide, apex of fore wing pads only slightly extending beyond base of hind wing pads, rudiments of gonapophyses not reaching tip of abdomen ..... INSTAR III

   Wing pads well developed, much longer than wide, fore wing pads subcoextensive with hind wing pads, gonapophyses more or less reaching tip of abdomen 4

4. Wing pads not reaching beyond anterior third of abdomen, and certainly not beyond third abdominal segment, last abdominal tergite not longer than wide, at most as long as wide..... INSTAR IV

Wing pads reaching to one half length of abdomen, last abdominal tergite much longer than wide..... INSTAR V

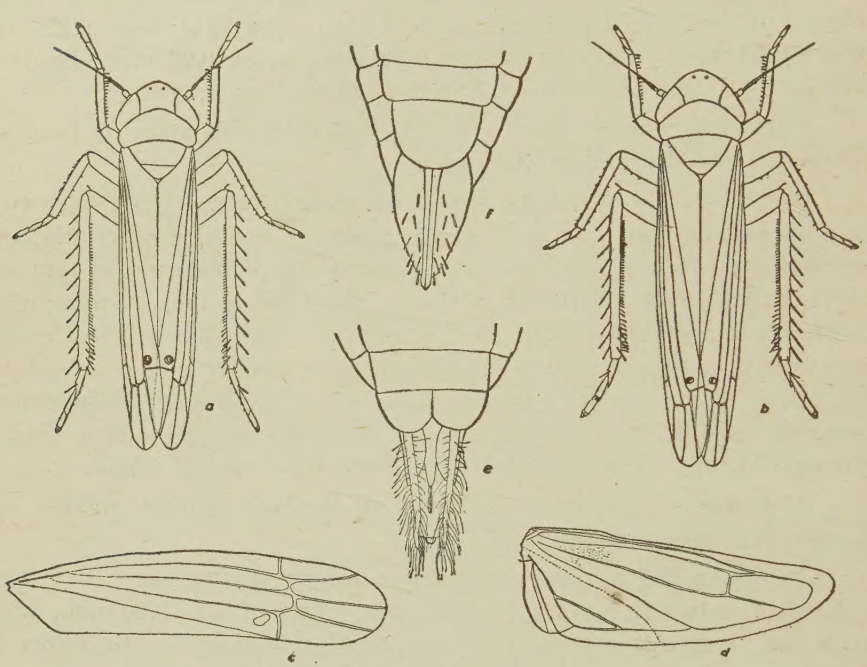

Fig. 2.—(*a*) Adult male, dorsal aspect (× 18); (*b*) adult female, dorsal aspect (× 17); (*c*) right fore wing (× 23); (*d*) right hind wing (× 21); (*e*) tip of abdomen of adult male, ventral aspect (× 36); (*f*) tip of abdomen of adult female, ventral aspect (× 36).

Adult male. [fig. 2 (*a*)]. General color of body yellowish green, darker green on legs; fore wing light yellow, with a pinkish tinge at apex. Head light greenish yellow dorsally, clypeus green; pronotum with three light spots, one median and one on each side; scutellum with three similar spots.

Head subconical from dorsal aspect, triangular from frontal and lateral aspects; about one-ninth total length of body. Labium subcylindrical, three-segmented; segment I subcylindrical, glabrous, about one and one-half times as long as broad, about one-fourth total length of labium; II subcylindrical, covered with fine hairs, diameter about four-fifths that of I, two and one-half times as long as broad, about one and one-half times as long as I; III elongately subpyriform, covered with fine hairs, length about one and one-fourth times that of II, diameter slightly smaller, apex blunt.

Maxillary seta filiform, about one and one-fourth times as long and about one-eighth as wide as labium. Mandibular seta filiform, about three-fourths as long as labium, of the same diameter as maxillary seta. Labrum small, elongately subtriangular, about one-third as broad and almost as long as labial segment I, and about twice as long as broad. Clypeus subtriangular, about three times as long as labrum, about one and one-third times as long as broad. Genae prominent. Frons subrectangular, attenuated distally, about twice as long as broad. Antenna setaceous, many-segmented, length about one and one-fifth times the width of head. Scape short and stout, slightly wider toward distal end, as long as broad. Pedicel subcylindrical, length about one and one-half times that of scape, about one and one-half times as long as broad. Flagellum twelve-segmented, about one-third as broad and about nine times as long as pedicel; first segment coarctate, succeeding segments gradually decreasing in diameter; sixth segment with antennal bristle almost as long as segment;. twelfth segment about two-thirds entire length of clavola. Ocelli present. Vertex obtusely-angulate. Eyes large and prominent, irregularly subhemispherical, purplish black.

Thorax about one-third total length of body, about one and one-fourth times as long as broad. Pronotum subreniform, anterior margin convex, posterior margin concave, about one-fourth as long as broad, almost as broad as head. Scutellum triangular, about one and one-half times as long and about three-fourths as broad as pronotum, about four-fifths as long as broad, produced into an acute angle distally, with a transverse suture one-third the distance from apical angle. Metathorax subequal in length and width to mesothorax, about four-fifths as long as broad. Prothoracic leg covered with numerous hairs. Coxa subcylindrical, sparsely covered with minute hairs, about twice as long as broad; trochanter acutely angulate distally, about twice as long as broad; femur somewhat enlarged at the middle, about twice as long as coxa, with minute hairs distally, about four times as long as broad. Tibia subcylindrical, subequal in length and about two-thirds as broad as femur, about eight times as long as broad, setae arranged in a linear row. Tarsus about one-half as long and about four-fifths as broad as tibia, three-segmented, sparsely covered with fine hairs; segment I about twice as long as broad; II about twice as long as broad, and about one and one-third times as long and almost as broad as I; III about two and one-half times as long as broad, slightly broader than II. Unguis about one and one-half times as long as breadth at base, about one-third as long as III. Mesothoracic leg almost as long as prothoracic and similar in relative proportion, differing from latter in that the coxa is shorter, femur not enlarged at middle, linear bristles on tibia less conspicuous. Me-

tathoracic leg about one and one-third times as long as mesothoracic, differing from both pro- and mesothoracic legs as follows: shorter and less prominent coxa; a bristle at distal end of femur; femur five times as long as broad; tibia one and one-half times as long as femur, beset with double rows of spines, medial side with short bristles proximally and long bristles distally; tarsus one and one-half times as long as either pro- or mesothoracic, three-segmented, I about one-third total length of tarsus, four times as long as broad, with two spurs, one ectodistal and the other entodistal, II almost as long and as wide as I; III about three-fourths as long as I.

Fore wing [fig. 2 (*c*)] elongately subelliptical, about three and one-half times as long as broad, apex extending beyond posterior end of abdomen, glabrous, somewhat thickened; four longitudinal veins and four apical cells, the latter occupying distal fourth of wing; a brownish black spot bordering distal third of outer margin between two longitudinal veins. Hind wing [fig. 2 (*d*)] membranous, uniformly hyaline, subtriangular, length about four-fifths that of fore wing, about twice as long as broad, rounded at apex, broadly arcuate at inner margin.

Abdomen ovate in dorsal outline, about three-fifths total length of body, about twice as long as wide, slightly broader than thorax; nine-segmented, first abdominal segment about three-fifths as wide as second abdominal segment, the rest of the segments subequal in length except the last; last abdominal segment tubular, about twice as long as preceding segment. Abdominal setae inconspicuous. The genital organs are shown in figure 2 (*e*).

An apparently average-sized male measured as follows: Length of body (exclusive of appendages) 2.35 mm., width 0.65 mm.; length of head 0.25 mm., width 0.55 mm.; length of antenna 0.65 mm., width 0.04 mm.; length of fore wing 2.05 mm., width 0.45 mm.; length of hind wing 1.85 mm., width 0.75 mm.; length of fore leg 1.50 mm., of middle leg 1.70 mm., and of hind leg 2.90 mm.

Adult female. [fig. 2 (*b*)]. General color of body yellowish green, usually darker green than the male, especially on the thorax and legs.

Female conspicuously larger than the male. Very similar to the male in body proportions and characters of appendages. Differs from the male in the following features: spot on the wing much smaller, about two-thirds as small as in male; abdomen elongately conical, widest at mid-abdomen.

The genital organs are shown in figure 2 (*f*).

An apparently average-sized female measured as follows: Length of body 2.65 mm., width 0.65 mm.; length of head 0.25 mm., width 0.60 mm.;

length of antenna 0.70 mm., width 0.05 mm.; length of fore wing 2.15 mm., width 0.60 mm.; length of hind wing 1.90 mm., width 0.80 mm.; length of fore leg 1.50 mm., of middle leg 1.70 mm., and of hind leg 2.85 mm.

Newly emerged adults are whitish green with the black spots on the wings not yet visible. They assume their characteristic color three hours after emergence.

Adult hoppers are generally found on the undersurface of the leaves where they feed near the edges. Adults feed on the same leaf as the nymphs and remain there unless disturbed. On young plants they are found on the oldest leaves, whereas on old plants the younger leaves are preferred although no hoppers are on the youngest leaves. As the plants grow older and there are younger plants nearby, the latter soon become infested while the old plants become almost free from hoppers. Hoppers seen on the veins or petiole are usually gravid females. Adults when exposed directly to sunlight die after an hour or so.

Copulation was observed in the field during cooler parts of the day, usually early in the morning and late in the afternoon. The longest duration of mating observed was one and one-half hours. Hoppers were not observed to mate in the laboratory when confined in breeding cages. There was only one instance when a male was observed to mate one day after emergence, the mating lasting for about fifteen minutes.

The longevity of male adults in confinement was from one to eight days, three days being about the average. During the dry season many of the adults died one day after emergence. Females also in confinement may live as long as 36 days, the average being about 19 days.

The female lays her eggs by piercing the side of the vein with her ovipositor. She lays only one egg to a puncture as seen from dissections of plant tissues. As has been mentioned above, adults were not observed to mate in the breeding cages. The number of young that a female may be able to produce could therefore not be determined. Eight females caught right away after mating in the field and allowed to oviposit in confined plants produced 4 to 11 eggs each till they died, the average being 8 eggs. Of course, it could not be ascertained how old these females were and whether they had previously laid some eggs. Several gravid females, also from the field, when dissected and the ovarian contents examined, showed only four or five mature eggs ready to be laid.

For the reason that adults do not seem disposed to mate in confinement, the period from emergence to copulation and to oviposition could not be ascertained. The adult females which were caught in the field and confined after being mated for oviposition, laid eggs one to two days after mating.

Counts of adults in the field seem to show a slight predominance of the females. In one count there were 33 females to 17 males, and in another there were 28 females to 22 males. While no more extensive count was made, a slight predominance of females over males is to be expected, since females are longer-lived than males.

HOST PLANTS

Silvestri (1934) reported that *Empoasca flavescens* feeds on many herbaceous plants, particularly the leguminous and solanaceous plants, but in their absence it may feed on shrubs and vines.

In the present work, the pest was observed on eggplant, cotton (*Gossypium* spp.), okra [*Abelmoschus esculentus* (Linn.) Moench.], and on *Solanum mammosum* Linn., to the exclusion of many other plant species examined.

On cotton the effects of feeding are first noticed on young plants by the wilting of the edges of the leaves, which afterwards curl inward. The attacked leaves may or may not turn yellow, and after a few days they dry up, appearing as the characteristic hopperburn effect. On older plants the leaves curl inward and the edges gradually dry up and become brittle. Plants infested with hoppers are stunted and unthrifty in appearance.

In the case of cotton, around five to ten hoppers feeding on a leaf in a day are enough to cause wilting and "burning" of the leaf. The wilted leaf becomes dry and brittle within three or four days. It was noted in the study that two potted cotton seedlings confined and subjected to the feeding of ten adult hoppers died after the latter had fed on them continuously for one week.

The other host plants are not so susceptible to the attack of the pest as cotton. The leaves of the eggplant and okra turn yellow at the edges, which finally dry up. During the months of March and April, when the pest was most abundant, the eggplants suffered severe hopperburns, whereas on rainy months the plants suffered little if at all.

Hoppers, which superficially may be taken for *Empoasca flavescens*, were observed on sitao (*Vigna sesquipedalis* Wight), cowpea (*Vigna sinensis* Endl.), soybean, peanut, and mungo (*Phaseolus aureus* Roxb.). Closer examination, however, revealed that the hoppers were of a different species. They are larger, darker green than *Empoasca flavescens* and lack the black spot on each wing. A very similar hopper was seen on *Urena lobata* Linn., *Triumfetta semitriloba* Linn., *Triumfetta bartramia* Linn., and *Solanum verbascifolium* Linn. This hopper resembled the species studied except

for the spot on the wings. Leaves on which this species fed turned yellow at the edges.

SEASONAL DISTRIBUTION

The monthly field count of hoppers per leaf made on the eggplant (the long, purple variety for the Native, and the round, purple variety for the American eggplant were used) is presented graphically in figure 3.

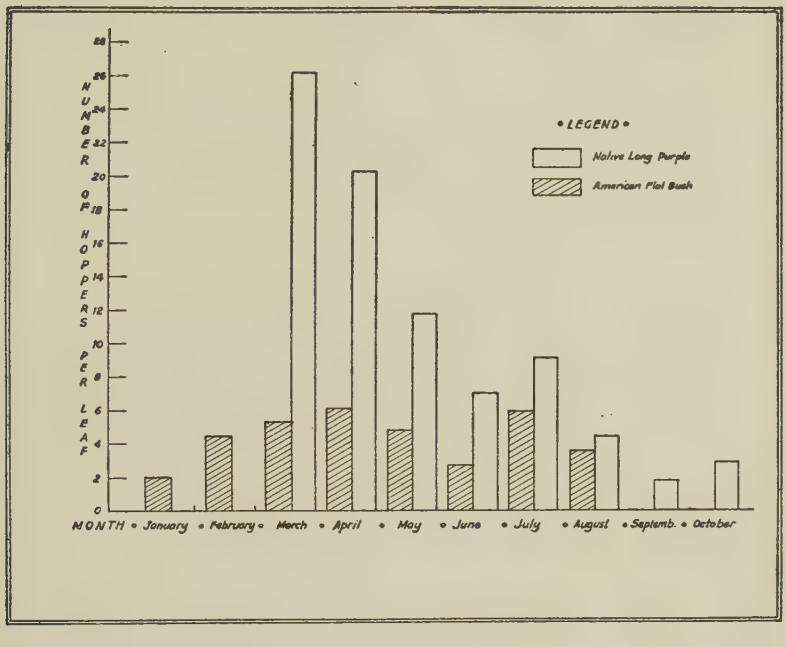

Fig. 3.—Monthly abundance (weekly averages per leaf from fifty leaves) on two varieties of eggplant.

The results show that the number tends to increase during the drier months and tends to decrease during rainy months. The pest was most abundant during the months of March and April (more so during April), decreased in June, increased again in July, and finally dropped off during the succeeding rainy months. As the warmer months approached there was a tendency for the pest to increase.

At all times the nymphs were present in larger numbers in the field than the adults. It was also observed that the hoppers preferred younger plants to mature plants.

It would seem, therefore, that in order to avoid excessive hopper injury, planting at the proper time may be resorted to, in order to have the plants almost mature by the time the hot months come.

NATURAL ENEMIES

During the study, six species of spiders[3] were observed to prey on the hoppers. The spiders locate themselves on the undersurface of the leaves and grasp their prey. Adults as well as nymphs are fed upon by the spiders. No other predator or parasite was observed.

In the latter half of August, 1946, and during the whole month of September, 1946, when it was very rainy, numerous adults and nymphs were killed by a fungus which was identified by Dr. G. O. Ocfemia of the Department of Plant Pathology as *Cephalosporium* sp. The insects that were attacked were seen attached to the leaves, with the pinkish white growth of the fungus over them. On plants where many hoppers were thus killed by the fungus, very few hoppers were observed thereafter. When conditions are favorable, this fungus is evidently an important factor in the control of the pest.

RESISTANCE OF DIFFERENT VARIETIES OF THE HOST PLANTS

Figure 3 also presents the relative infestation by *Empoasca flavescens* of two varieties of the eggplant, the Native Long Purple and the round-fruited American variety, Flat Bush. The result is summarized in table 4. Where counts could be made simultaneously for the two varieties, there were consistently more hoppers on the Native Long Purple than on the Flat Bush. This difference is statistically significant. The two varieties were not very far from each other. It can be concluded then that the variety Flat Bush is not so severely attacked by *Empoasca flavescens* as the Native Long Purple.

It is very likely that the preference of the hopper for a certain variety of the eggplant depends upon the texture of the leaves. Native Long Purple has soft, pubescent leaves, while Flat Bush has thick leaves with stiff hairs. These varietal differences in the host plants may be responsible for the difference in degree of susceptibility to hopper attack.

With cotton, only the following varieties were available for observation: Batangas White, Ilocos White, Ferguson, and tree cotton. Batangas White, Ilocos White, and Ferguson are hirsute, with long and thick hairs. The tree cotton has glabrous leaves, but with a fairly thick cuticle.

The weekly field count of hoppers per leaf on these varieties is shown in table 5. The first observation was made when the plants were two weeks old and continued until the plants were seven weeks old. At this latter stage the plants were already blooming. No further counts were made after this period because very few hoppers could be found on the plants,

[3] Deposited in the Department of Entomology for future identification.

and the plants at this stage had apparently passed the critical period for hopper injury.

Table 5 shows that the tree cotton seems the least susceptible since it had the lowest count of hoppers. This is, however, more apparent than real, for the statistical analysis of the results shows that there was no significant difference among the four varieties tested.

The cotton plants were planted in June, when the relative number of hoppers was low, so that there were not enough hoppers to cause much damage. The plants were rank-growing but they did not form many squares. Observations showed that the critical age of the host for leafhopper injury seems to be in the stage of early growth of the plants.

The seasonal distribution of the pest suggests as a possible method of preventing the heavy infestation of the hopper the adjustment of the time of planting so that the early stage of growth of the plants, which is most susceptible to the attack, will not coincide with the months when the pest is most abundant.

CONTROL METHODS

DDT-boosted kerosene emulsion. In the laboratory, all the nymphs were killed within two hours after being sprayed with DDT-boosted kerosene emulsion. None of the nymphs in the control (sprayed with plain tap water) were dead within the time. Of the adult leafhoppers, 45 per cent died within one hour after spraying with DDT-boosted kerosene emulsion, while none in the control lot died within one hour; all adult hoppers died within two hours after spraying with the emulsion, but only 23 per cent in the control lot died within the time. The appreciable difference shows the effectiveness of DDT-boosted kerosene emulsion for killing *Empoasca flavescens.*

In the field, the treated lot (sprayed with DDT-boosted kerosene emulsion), had an average of 3.3 hoppers per leaf before spraying, but on the day after spraying, there were absolutely no hoppers. The control lot (sprayed with plain tap water) had an average of 3.0 leafhoppers per leaf before spraying; the number (3.5 hoppers per leaf) was not reduced one day after spraying.

The efficacy of DDT-boosted kerosene emulsion in killing *Empoasca flavescens,* is, therefore, conclusive.

A few leaves of the eggplant sprayed with the emulsion showed injury in the form of spots as a result of the treatment, especially where there was an excess of spray applied on the leaves. This injury became noticeable on the day after the application of the spray. Where the application was not excessive and the spray broke into fine mist, there was no noticeable

injury. Since the injury was very slight and could apparently be corrected by applying the spray not too excessively and in mist form, this injury to eggplant may be ignored.

The emulsion did not show any injury on the cotton varieties used.

DDT dust. In the field, there was an average of 4.7 leafhoppers per leaf before dusting, but on the day after dusting, no hoppers could be found on the treated plants. In contrast, the initial number of leafhoppers in the control (undusted) lot was 2.5 per leaf, and on the following day this number, remained practically the same, that is, 2.7 hoppers per leaf.

No injury resulting from the application of 10 per cent DDT dust was observed on the dusted plants.

SUMMARY OF CONCLUSIONS

1. The total developmental period of *Empoasca flavescens* under laboratory conditions ranged from 11 to 17 days, with an average of 14.2 days, in the male, and from 12 to 18 days, with an average of 14.8 days, in the female.

The different stages of development of the pest under laboratory conditions are as follows:

Incubation period—5 to 9 days (usually 6 to 7), average 6.6 days for the male; and 5 to 8 days (usually 6 to 7), average 6.8 days for the female.

First stadium—1 to 2 days, average 1.45 days for the male, and 1.48 days for the female.

Second stadium—1 to 2 days (usually 1 day), average 1.20 days for the male, and 1.37 days for the female.

Third stadium—1 to 3 days (usually 1 day), average 1.33 days for both sexes.

Fourth stadium—1 to 4 days (usually 1 or 2 days); average 1.55 days for the male and 1.75 days for the female.

Fifth stadium—1 to 4 days (usually 2 days), average 2.03 days for the male, and 2.06 days for the female.

2. When confined in cages, the adult male lives 1 to 8 days (average 3 days) after emergence; the female lives 1 to 36 days (average 19 days) after emergence.

3. The eggs are laid singly in the tissues of the plants, mostly in the veins and petiole of the leaves.

4. The nymphs and adults feed on the undersurface of the leaves. The feeding of the adults causes hopperburn on the leaves, which results in stunted and unhealthy plants.

5. *Empoasca flavescens* was observed to feed in the field on cotton (*Gossypium* spp.), eggplant, okra (*Abelmoschus esculentus* (Linn.) Moench.), and on *Solanum mammosum* Linn.

6. The cotton leafhopper tends to become more abundant during the drier months, especially in April and March, than during the rainy months of the year.

7. The pest is partial to certain varieties of eggplants. The Native Long Purple variety is more susceptible than the Flat Bush.

There was no significant difference in susceptibility to the hopper among the Batangas White, Ferguson, Ilocos White, and tree cotton.

8. Six species of spiders were observed during the study to prey on the nymphs and adult hoppers in the field.

A fungus, *Cephalosporium* sp., killed both nymphs and adults during the rainy months.

9. DDT, either in the form of DDT-boosted kerosene emulsion spray or a 10 per cent dust, was effective for controlling the pest.

10. There seems to be a possibility of avoiding serious hopper injury to cotton through proper timing of the planting so that the plants may be sufficiently grown to resist damage when the pest becomes most abundant in the dry warm months.

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TABLE 1

Summary table comparing the incubation period for the male and the female

SEX	NUMBER OF INDIVIDUALS	DEGREES OF FREEDOM	MEAN	SUM OF SQUARES
Male.....	58	57	6.6	46.48
Female.....	52	51	6.8	26.68
		Sum = 108	d = 0.2	Sum = 73.16
Pooled variance = 0.677	s = 0.81	t = 0.15 (insignificant)		

TABLE 2

Summary table comparing the developmental time of the nymphal stage for the male and the female

SEX	NUMBER OF INDIVIDUALS	DEGREES OF FREEDOM	MEAN	SUM OF SQUARES
Male.....	58	57	7.55	61.00
Female.....	52	51	8.00	52.34
		Sum = 108	d = 0.45	Sum = 113.24
Pooled variance = 1.05	s = 1.02	t = 2.37 (significant)		

TABLE 3

Summary table comparing the total developmental periods (egg to adult) for the male and the female

SEX	NUMBER OF INDIVIDUALS	DEGREES OF FREEDOM	MEAN	SUM OF SQUARES
Male.....	58	57	14.2	128.72
Female.....	52	51	14.8	80.68
		Sum = 108	d = 0.6	Sum = 209.40
Pooled variance = 1.94	s = 1.39	t = 2.22 (significant)		

TABLE 4

Summary table comparing abundance of hoppers on eggplant varieties Flat Bush and Native Long Purple

VARIETY	NUMBER OF OBSERVATIONS	DEGREES OF FREEDOM	MEAN	SUM OF SQUARES
Flat Bush.....	17	16	4.70	53.53
Native Long Purple...	17	16	11.90	767.06
		Sum = 32	d = 7.20	Sum = 820.59
Pooled variance = 25.64	s = 5.06	t = 4.16 (highly significant)		

TABLE 5

Weekly hopper-per-leaf counts on four cotton varieties in the field

DATE	VARIETIES											
	Batangas White			Ferguson			Ilocos White			Tree Cotton		
	Adult	Nymph	Total	Adult	Nymph	Total	Adult	Nymph	Total	Adult	Nymph	Total
1946	*number*	*number*	*number*	*number*	*number*	*number*	*number*	*number*	*number*	*number*	*number*	*number*
July 6	0.58	1.10	1.68	0.65	1.10	1.75	0.93	0.95	1.88	0.409	0.909	1.32
July 14	0.40	3.54	3.94	0.36	2.58	2.94	0.52	3.64	4.16	0.24	1.46	1.70
July 21	0.82	0.60	1.42	0.60	1.42	1.84	0.52	1.52	2.04	0.42	1.04	1.46
July 28	0.46	0.86	1.32	0.98	0.74	1.72	0.90	0.72	1.62	0.50	1.00	1.50
August 10	0.68	1.16	1.84	0.62	2.02	2.64	0.50	1.38	1.88	0.52	0.82	1.34
August 17	0.60	0.36	1.46	0.52	1.42	1.94	0.70	1.44	2.14	0.88	0.44	1.32
Mean			1.91			2.14			2.29			1.44

HETEROSIS IN TOMATO[1]

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WITH TWO TEXT FIGURES

The tomato is one of the crop plants particularly suited to hybrid seed production, owing to the simplicity of its flower structure, abundance of seed produced, and the ease with which the flowers can be handled. The present experiments which were performed in the culture plots of the Department of Agricultural Botany from October, 1945, to January, 1947, were made with a view to discovering first-filial combinations between native and some apparently disease- and pest-resistant local tomato varieties. The objects of these experiments were: (*a*) to determine heterosis in the first-filial-generation crosses between local varieties of tomato, (*b*) to record fruit and plant characters which have been affected by hybrid vigor, and (*c*) to recommend the best hybrid combination for the utilization of hybrid seed in tomato improvement work.

A number of studies have been made on heterosis. Wellington (1912) reported increases in earliness and productivity among several of his varietal hybrids and concluded that the F_1 crosses were of sufficient value to compensate the cost of producing crossed seed.

Hayes and Jones (1916) reported that the lowest increase in yield over the better parent was 11 per cent, and the highest, 17 per cent. The F_1 hybrid averaged 15 per cent more fruit by weight than the better parent.

Hepler (1929) observed that hybrid tomatoes are notably more vigorous and productive than the parental types and asserted that the increased yields were due to a larger number of fruit which averaged somewhat smaller than the fruit of the parents, often being comparable in size to those of the smaller-fruited plant.

Whaley (1939) pointed out that heterosis produced its effects by influencing total plant size, and that whereas the size of the determinate organs is not increased, the organs themselves are produced in great numbers.

Burgess (1941) likewise pointed out that crosses of horticultural varieties yielded first-generation progeny that were in many instances more productive of early, marketable fruit than one, and often both, of the parents.

[1] Experiment Station contribution No. 1456. Portions of the data used here were included in a thesis presented by the junior author for graduation, 1947, with the degree of Bachelor of Science in Agriculture.

Meyer and Peacock (1941) observed that certain hybrids of standard varieties of tomatoes proved superior to their parents with respect to early total yields.

MATERIALS

Tomato strains used

Native. Few branches, which shoot obliquely upward, grow from the principal stem. The flowers are borne in clusters. The fruit, which has a flesh of medium thickness, is generally ridged and is sometimes curled at the two ends. The fruit has an average equatorial diameter of 4.46 centimeters. The ripe fruit is red. Compared with the wild tomato in flavor, the Native tomato is relatively sweet. The leaves are odd-pinnate with doubly dentate dark green leaflets. Pubescence is almost absent. This strain thrives well in well-drained sandy loam soil and is grown from November to March.

Susong Kalabaw (plum type). Main branches grow from the principal stem at a point close to the ground. Both flower and fruit are produced in clusters. The smooth-skinned and plum-shaped fruit is deep red when ripe. It is thick-fleshed and relatively sweet in taste. The leaves are similar to those of the native variety in texture, but are narrower and have deeper incisions, sometimes going as deep as the midrib of the leaflets. This strain grows well in well-drained sandy loam soil. It is grown from November to March.

Kamatis na Ligaw (wild-cherry type). The spreading growth habit of the plant gives it a distinctly bushy appearance. Numerous small flowers are produced in clusters. The fruit is spherical, with an average diameter of 1.54 centimeters. The fruit color varies from yellowish-pink to deep red. The plant produces many sour thin-fleshed and seedy fruit. The leaves, which have medium pubescence, are odd-pinnate and are composed of small, light-green leaflets. This strain grows throughout the year and thrives in almost any kind of soil.

EXPERIMENTAL PROCEDURE

Seed preparation and seed-bed culture

Selected ripe fruits of the three varieties of tomato were cut open crosswise and the seeds pressed out into separate vessels. The seeds were allowed to stand in the vessels overnight to bring about fermentation in order to facilitate the removal of the jellylike mass adhering to the seeds. The seeds were then washed, cleaned, and spread on cloth squares. Then the seeds were dried thoroughly.

The soil was thoroughly pulverized and the seedbed well prepared to insure proper drainage. To separate the varieties, the bed was divided into three parts, each variety occupying a part. The seeds were planted in the seed bed on October 15, 1945, and they germinated on October 20 to 23, 1945.

Pot culture

Transplanting of the seedlings into pots was done 28 days after germination. Pot culture was resorted to in order to insure survival of the plants. Nine eight-inch pots were filled with sterilized soil. Three healthy and vigorous seedlings of each variety were selected. One seedling was allowed to each pot. In all cases, the potting was done on the same day. The individual plants were kept separately at different points of the field to provide as nearly equal conditions as possible. The plants were staked and trained to a single stem.

Technique of controlled pollination

An earlier observation in the experiment revealed that the pollen of tomato plants dehisced between nine o'clock and twelve o'clock in the morning. This preliminary observation served as a guide in timing the emasculation. Flower buds that appeared were properly labeled in the afternoon to facilitate identification. Early the next morning, the tagged flowers which were about to open were emasculated and bagged.

Emasculation. Emasculation was done by splitting wide open the corolla with sharp, pointed forceps. The five stamens were then pulled out at their basal ends one at a time in order to minimize chances of injuring the style in the operation.

Artificial pollination. To insure fertilization, cross-pollination of the emasculated flower was done the following morning at eleven o'clock, when the stigma was highly receptive. Receptivity of the stigma is indicated by the moist and sticky appearance of its surface. Stamens were secured from the open flowers of the previously bagged male parents, Susong Kalabaw and Kamates na Ligaw. The anthers of the male parent were gently rubbed on the surface of the stigma of the pistillate flower which had been previously emasculated.

Care of pollinated flowers. Soon after cross-pollination, all the untreated flowers in the same cluster were removed. The treated plants were properly labeled to indicate the combination accomplished, the date of emasculation, and the date of cross-pollination. Throughout the whole operation the usual precautions were taken to prevent contamination. The treated flowers were frequently inspected and proper care was given them.

Crosses performed

In these experiments the native variety was the maternal or pistillate parent and the source of the hybrid seed, whereas Susong Kalabaw and Kamatis na Ligaw were pollinators. The following combinations were effected: (*a*) Native × Susong Kalabaw, and (*b*) Native × Kamatis na Ligaw.

Parallel culture of parental types and hybrids

The nursery bed. Five hundred seeds of each individual strain, both parents and hybrids, were sown on a 61.0 cm. × 152.5 cm. (two by five feet) seed box filled with pulverized soil which had been previously sterilized. To prevent the seeds from being eaten by ants, the base of each leg of the seed box was set in a can of water.

The seeds of the following strains were planted in the box on May 5, 1946: (1) Native variety, (2) Susong Kalabaw, (3) Kamatis na Ligaw, (4) (Native × Susong Kalabaw) F_1 hybrid, and (5) (Native × Kamatis na Ligaw) F_1 hybrid.

The seeds germinated on May 8, 1946. Thinning was done on May 9, 1946. During the first week the seedlings were completely shaded and were watered every afternoon. Then the plants were exposed to sunlight from morning till noon for a week and were watered every two days. During the third week, the seedlings were exposed to sunshine during the whole day for hardening in preparation for transplanting to the field.

Transplanting the seedlings. Thirty of the most vigorous seedlings from each variety were selected and transplanted on June 11, 1946. The plot consisted of ten rows with fifteen hills in each row. The seedlings were set at a distance of 80 centimeters from each other in the rows which were one meter apart. The 150 plants (30 plants for each strain) were planted in such a way that there would be no possibility that the difference of fertility of the field would play a rôle in the developmental behavior of the plants. Observations on the first-generation plants were made regarding dates of blooming of both parents and hybrids, periods of fruiting and death, and resistance to diseases and pests of each variety.

Laboratory study of fruit characters. For purposes of laboratory study, five fruits were taken from each plant and their measurable characters were observed. The following characters of the fruit of each variety were studied:

(*a*) *Polar diameter.* The vertical distance from the base to the tip.
(*b*) *Equatorial diameter.* The horizontal distance across the greatest width.
(*c*) *Weight of the fruit.*

(*d*) *Number of locules in each fruit.* Each fruit was cut open crosswise and the number of locules counted.

(*e*) *Keeping quality of the fruit.* The keeping quality of the fruits under ordinary room temperature.

(*f*) *Shape and taste of the fruits.*

RESULTS AND DISCUSSION

Percentage of germination

The percentages of germination of the hybrid seeds were higher than those of the parental types, the former giving a range of 25 to 30 per cent and the latter, 15 to 25 per cent. The hybrids were found to grow more

Fig. 1.—Seedlings of the five strains, a day before they were transplanted.

rapidly than either parent in the early stage of growth (fig. 1). In the later stages of development no marked difference in plant size between the hybrids and the parents was observed.

Variation in flowering of the five strains

The two first-generation hybrids flowered earlier than either of the parents. Hybrid vigor, on the basis of earliness of flowering, was manifested in the first-generation crosses. Kamatis na Ligaw, which is an early fruiting strain, flowered later than the hybrid (Native × Kamatis na Ligaw) F_1, in spite of the fact that the Native variety, the female parent, is a late-flowering variety.

Variation in fruiting of parental types and F_1 plants

The two hybrids, as expected from their early flowering, formed fruit the earliest.

One interesting feature is that although the hybrid (Native × Susong Kalabaw) F_1 (fig. 2) had already produced numerous fruit, the two parental strains, the Native and the Susong Kalabaw, had not as yet formed a single fruit. The other hybrid, (Native × Kamatis na Ligaw) F_1, at any single time until maturity had more plants fruiting than either of its parents.

Variation in longevity periods of the five strains

The hybrid (Native × Susong Kalabaw) F_1 died the earliest. Of the parental types, the Native strain had the shortest longevity period. The same number of plants of the hybrid (Native × Kamatis na Ligaw) F_1

Fig. 2.—(Native × Susong Kalabaw) F_1 tomato at the height of fruiting.

and of its parental type, Kamatis na Ligaw, died during a certain period. The Kamatis na Ligaw and the Susong Kalabaw died the latest.

Plants were counted as dead only when all the leaves, stem, and branches had dried up.

Variation in polar diameter of the fruit

The (Native × Kamatis na Ligaw) F_1 fruit had an average polar diameter smaller than the polar diameter of the Native, but greater than that

of the Kamatis na Ligaw. This observation confirms the findings of Hacborth (1940) that in the breeding of tomatoes, fruit size is the most difficult goal to attain since the small size of the parent species appears to dominate the cross. The (Native × Susong Kalabaw) F_1 had a greater average polar diameter than either of the two parents, as shown in table 1, and the differences in the polar diameters of the five strains were highly significant.

Variation in equatorial diameter of the fruit

The fruits of the two hybrids had greater equatorial diameters than their respective male parents. The (Native × Kamatis na Ligaw) F_1 fruit had a very much smaller average equatorial diameter than the fruit of the Native. The (Native × Susong Kalabaw) F_1 fruit had almost the same average equatorial diameter as the Native.

Variation in the number of locules in the fruit

As shown in table 1, with respect to the number of locules in the fruit, the Native was apparently dominant over the male parents, Susong Kalabaw and Kamatis na Ligaw. The differences in the number of locules in the fruits of the five strains were highly significant.

Variation in weight of fruits of the five strains

The hybrid (Native × Susong Kalabaw) F_1 produced fruit almost as heavy as those of the Native variety (fig. 2). This may be explained by the fact that although smaller in size, Susong Kalabaw has a thicker flesh and a greater polar diameter than the Native. The fruit of the (Native × Kamatis na Ligaw) F_1 hybrid generally weighed about one-fourth that of the Native.

Variation in number of fruit produced by each of the five strains

The Native was the poorest producer probably because it was grown out of season. The two hybrids produced more than the Native but less than their male parents. There was little difference between the quantity of fruit produced by the hybrid (Native × Kamatis na Ligaw) F_1 and that by Kamatis na Ligaw. The difference in the number of fruit produced by each of the five strains was highly significant, as shown in table 1.

Comparative features of the parental varieties and their first-generation hybrids

(Native × Susong Kalabaw) F_1. The general appearance of the plant is like that of the Native parent. Since the fruit of this hybrid is almost

spherical and ridgeless, and has a greater polar diameter than that of the Native, it is of a more desirable shape than that of the parents. The fruit is thick-fleshed and relatively sweet, like that of the Susong Kalabaw.

(*Native* × *Kamatis na Ligaw*) F_1. The general appearance of this hybrid is like that of the Kamatis na Ligaw. The fruit is very much smaller than that of the Native, but it is bigger than the fruit of Kamatis na Ligaw. The shape of the fruit is like that of the Native although the ridges are less pronounced. The fruit is relatively sweet, like the Native tomato.

Variation in keeping quality of the fruits

Observations on the keeping quality of the fruits of the five strains under ordinary room temperature showed that the fruit of the hybrid (Native × Kamatis na Ligaw) F_1 kept for 21 days; the (Native × Susong Kalabaw) F_1 and the Susong Kalabaw, 11 days; the Kamatis na Ligaw, 6 days; and the Native, 5 days. From these findings, we can deduce that the fruits of the two hybrids have better keeping quality than those of their parents.

Pests and diseases

Epilachna spp. badly attacked the Native and the (Native × Susong Kalabaw) F_1 plants during the fruiting stage. The leaves were skeletonized and the bark of the stem and the branches was chewed off. The Susong Kalabaw, Kamatis na Ligaw, and (Native × Kamatis na Ligaw) F_1 were hardly affected by this pest.

The (Native × Kamatis na Ligaw) F_1 plants were attacked the most by the bacterial wilt caused by *Phytomonas solanaceara* (E.F.S.) Bergey *et al.* Most of the (Native × Kamatis na Ligaw) F_1, Susong Kalabaw, and Kamatis na Ligaw were the worst attacked. Kamatis na Ligaw is reputedly resistant to bacterial wilt, whereas the Native is susceptible. In this experiment, however, the Native and the (Native × Susong Kalabaw) F_1 were the most resistant to the wilt disease.

Occasional cracking of the fruit was observed. This phenomenon was observed after dry hot days following a heavy rain. The Susong Kalabaw fruits were slightly affected by cracking but many fruits of the Native and the (Native × Susong Kalabaw) F_1 were considerably damaged. The (Native × Kamatis na Ligaw) F_1 and the Kamatis na Ligaw were not affected by it. According to Uichanco (1915), fruit cracking "is not caused

by any organism but is rather a physiological derangement. It is caused by the existence of conditions favorable to root absorption while there is present a factor which hinders the growth of the fruit skin."

It is of interest to note that the tomato plants were planted out of season, during the period of strong wind and rain in July, August, and September, 1946. Most of the plants then were flowering and fruiting at the same time; hence shedding of flowers and a consequent decrease in the number of fruit were expected. Contrary to expectations, however, the plants fruited abundantly in spite of the inclement weather. To prevent the staked plants from being blown down by the strong wind, the upper parts of the stakes were tied to a common horizontal bar and the ends of the bar fastened securely to the fence of the experimental culture field.

SUMMARY AND CONCLUSIONS

1. Heterosis was manifested by the first-filial-generation crosses of (Native × Susong Kalabaw) and (Native × Kamatis na Ligaw) as follows: (*a*) the percentage of germination of hybrid seeds was higher than that of the parental types; (*b*) the hybrids flowered and fruited earlier than their respective parents; (*c*) the (Native × Susong Kalabaw) F_1 cross showed a bigger polar diameter than the parents, whereas the hybrid (Native × Kamatis na Ligaw) F_1 had an increase in polar diameter over the male parent; (*d*) the two hybrids had equatorial diameters greater than those of their respective male parents, but smaller than that of the Native; (*e*) both first-generation hybrids had more locules than their male parents, whereas the Native had the most locules in the fruit; (*f*) the (Native × Susong Kalabaw) F_1 fruit was almost as heavy as the Native fruit, and the fruit of the (Native × Kamatis na Ligaw) F_1 hybrid weighed only one-fourth as heavy as the Native, but four times heavier than that of the Kamatis na Ligaw; (*g*) each produced considerably more fruit than the Native, although less than its male parent; and (*h*) the flavor of the better-tasting parents was imparted to the hybrids.

2. Observations on the keeping quality of the fruits under ordinary room temperature showed that the fruits of the hybrids, (Native × Kamatis na Ligaw) F_1 and (Native × Susong Kalabaw) F_1, possess better keeping quality than either or both parents. This desirable character is important to consider in marketing tomatoes.

3. All the strains except the Native developed satisfactorily under the adverse weather conditions of July, August, and September, which are too rainy for tomato culture.

4. The Susong Kalabaw and the (Native × Kamatis na Ligaw) F_1 were attacked by the bacterial wilt. The Kamatis na Ligaw, which is re-

puted to be resistant to the common diseases of the tomato because of its wild characteristic, was attacked by the bacterial wilt. The Native and the (Native × Susong Kalabaw) F_1, however, showed considerable resistance to the disease.

5. The hybrid (Native × Susong Kalabaw) F_1 showed desirable market qualities as to shape, size, taste, keeping quality, and high productivity. Furthermore it developed well even under the unfavorable weather conditions prevailing in the present study.

6. Although the (Native × Kamatis na Ligaw) F_1 was found to be fourteen times more productive than the Native, its fruit were comparable in size only to the culls of the out-of-season Native variety, so that this hybrid may not be desirable for commercial culture.

7. Of the crosses effected, the (Native × Susong Kalabaw) F_1 combination may be recommended in practical utilization of hybrid seed in tomato improvement work.

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TABLE 1

Mean values of the fruit characters studied in five strains of tomato

FRUIT CHARACTERS	SUSONG KALABAW	(NATIVE × SUSONG KALABAW) F_1	NATIVE	(NATIVE × KAMATIS NA LIGAW) F_1	KAMATIS NA LIGAW	LEAST SIGNIFICANT MEAN DIFFERENCE [a]
Polar diameter in centimeters	3.09	3.42	3.23	2.26	1.54	0.16
Equatorial diameter in centimeters. .	2.45	4.19	4.46	2.73	1.63	0.20
Number of locules.....	2.07	3.42	3.76	2.54	2.09	0.28
Weight of fruit in gram	10.38	31.68	34.45	8.95	2.02	3.98
Number of fruit	32.44	16.68	7.33	92.80	108.96	14.98

[a] Based on the value of t at 5% level of significance.

AGRONOMIC CHARACTERISTICS OF (POJ 2878 × P.S.A. 14) F_1 SUGAR-CANE SEEDLINGS[1]

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WITH ONE TEXT FIGURE

It is believed that superior cane seedling varieties have a tendency toward "senile degeneration" so that in order to maintain a high level of production superior varieties should be developed. One method of improving the yield of sugar cane is the production of new varieties by hybridization. With the object of increasing the yield of this important crop, seedlings of crosses between two standard varieties, POJ 2878 and P.S.A. 14, were studied for the purpose of isolating the more promising ones.

Review of literature

Harrison (1919) reported that from one arrow of a variety of sugar cane subjected under conditions where it was impossible for its arrow to be either cross-fertilized by any other variety or fertilized by any other flower of its own kind, 267 different varieties were obtained.

Among the early local workers who reported great variability in important agronomic characters among seedling canes from parent varieties were Sumagit[2] and Florida.[3]

Mendiola (1921), who worked on not less than thirty varieties of sugar-cane-seedling hybrids, found the existence of an enormous variability in height, vigor, and position due to the effects of typhoon, growth habit, and stooling habit among the seedling plants of each variety.

Unite (1925) reported that young first- and second-generation sexual seedling canes of the same age and parentage showed a wide range of variation in total number of shoots.

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[1]Experiment Station contribution No. 1457. A part of the data reported in this paper was used by the junior author in a thesis presented for graduation with the degree of Bachelor of Science in Agriculture.

[2]SUMAGIT, F. S. A study of the variability with respect to diameter of stalk, breadth of leaf, total solids, stooling, flowering, and color of (C. A. C. 87 × Negros Purple) F_1 seedling plants. (Thesis presented for graduation with the degree of Bachelor of Agriculture, 1925. Unpublished.)

[3]FLORIDA, V. T. Variability in important agronomical characters among seedling canes from parent varieties H-227, Louisiana Striped, Cebu Purple, and Badila. (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture, 1926. Unpublished.)

Morales (1928), in his study of (P.B. 119 × C.A.C. 87)F_1 seedlings, found that there was a high degree of variability in the weight of stalks, average height of stalks, average diameter of stalks, length of internodes, and number of millable and nonmillable stalks. He also found that some apparently disease-free plants appeared among the hybrids.

The present work was conducted from November, 1945, to February, 1947, in the Experiment Station of the College of Agriculture to study the variability in characters of agronomic importance of (POJ 2878 × P.S.A. 14)F_1 seedling canes.

MATERIALS AND METHODS

Varieties used

The materials used were 208 (POJ 2878 × P.S.A. 14) F_1 cane seedlings. These hybrid seedlings were grown from seeds produced during the arrowing season of 1945-46.

The parent varieties used are described as follows:

P.S.A. 14 tillers heavily both in plant and ratoon crops; light green cane, becoming purple when exposed, erect, fair-sized internodes, medium in length, non-flowering, very susceptible to smut, resistant to mosaic, matures in 10 to 12 months, yields as high as 100 tons of cane per hectare, and softer than POJ 2878.

POJ 2878 is greenish white cane, turning yellowish white when mature, erect, remaining so unless blown down by strong winds, stools heavily, resistant to drought, and wet weather, resistant to insect pests and diseases, arrows very early and profusely, matures in 12 to 14 months, and yields as high as 205 piculs or more of sugar per hectare.

Hybridization work was done on November 20, 1945, with P.S.A. 14 as the male and POJ 2878 as the female parents. The Javanese method was used. Male arrows were cut, the cut ends submerged in a bottle of water, which was tied close to and above the female arrows. The male arrows were changed every other day, and the female arrows were bagged after pollination. The replacing of the male arrows was continued for about two weeks. When the cane fuzz began to fall off, the seeds were gathered from the female parents and were placed in paper bags for a few days to dry. Then they were sown in a seed box on December 3, 1945. After fourteen days, the seeds began to germinate. Twenty-one days after germination, the seedlings were pricked in the nursery plots of the Department of Agronomy.

Culture

Preparation of the land. The sugar cane seedlings were planted on a 158.35 square meter piece of land that had been previously planted to tomatoes. The soil was clay loam. After the land had been prepared, five furrows one meter apart and about thirty centimeters deep were made.

Treatment and transplanting of the seedlings. Before the cane seedlings were transplanted on June 27, 1946, they were watered. They were pulled from the nursery plots with the aid of a trowel. The upper one-third of the leaves were pruned to avoid wilting.

The seedlings were planted one meter apart between the rows and 75 centimeters between hills in the row. The rate of planting was one cane seedling to a hill.

Care of the plants. Eleven days after the cane seedlings were transplanted, a thoroughly mixed decomposed manure was applied at the rate of three kilograms a hill. Two days after the application of the manure, ammonium sulfate fertilizer was applied at the rate of 15 grams a hill, or 199.24 kilograms a hectare. A second application of the same amount of ammonium sulfate fertilizer was made a month after the first application. The fertilizer was applied at the base of each plant in a trench about five centimeters deep.

The cane seedlings were cultivated and weeded with a hoe whenever it was found necessary to do so. The prevalence of certain diseases was minimized by removing the diseased portions of the cane plants.

Observation of the seedlings in the nursery plot

Before each cane seedling was planted, the height from the base to the ligule of the youngest leaf was taken. The number of tillers of each seedling was recorded. Likewise, its vigor and the presence of pests and diseases were observed.

Harvesting and determination of variability among seedling plants at the age of 14 months

The seedling canes were harvested on February 17 to 19, 1947. The variability in character among the cane seedlings was observed during the early stages of their growth and at the age of about 14 months. Before the cane stalks were harvested, all the necessary data were recorded. Then, all of the millable and nonmillable stalks were cut at the base close to the ground and the tops or points for planting were severed. Variability in character among the seedling plants was observed. The observations are explained under Results and Discussion.

RESULTS AND DISCUSSION

Observations in the nursery plot

External appearance of the cane seedlings. The seedlings were healthy and vigorous. They were apparently free from pests and diseases; however, they varied very much in height and in the number of tillers.

Initial height of cane seedlings. At the age of five months the cane seedlings varied in height from 12 to 50 centimeters when measured from the base to the ligule of the youngest leaf.

Number of tillers. Of the 211 seedlings observed just before the transplanting for the initial number of tillers, 31.2 per cent had tillers. The number of tillers varied from one to four a seedling.

Field observations

Appearance of transplanted seedlings. The seedlings were transplanted on June 27, 1946, at the age of about six months. Owing to the cloudy weather during the transplanting, the seedlings did not suffer at all from exposure. As a matter of fact, they were observed to resume their normal growth a few days after transplanting.

Degree of tillering. Two months after transplanting, the seedlings appeared vigorous and produced many tillers. Weekly observations showed continued tillering and the production of the greatest number of tillers in August, 1946, or about two months after transplanting. From then on, there was a marked decrease in the number of tillers produced by a plant.

Accidental destruction of some seedlings. On December 21, 1946, the stalks of seedling Nos. 18, 19, 20, 62, 108, 109, 110, and 111 were completely destroyed accidentally and those of seedling Nos. 63, 64, 65, 66, 107, 112, 156, and 157 partly damaged. At this time the seedling plants were about 12 months old and had already stopped tillering. Furthermore, they had already long millable stalks. The broken stalks were collected and taken to the laboratory where the total weight of millable stalks, number, height, diameter, and length of internode of millable stalks, and the number of nonmillable stalks in each seedling cane were determined.

Flowering. None of the hybrid seedling plants showed any sign of flowering even after about 14 months from sowing in the seed bed, or about 9 months after transplanting. This is in favor of the seedlings from the standpoint of the farmer. The farmer utilizes the tops of nonflowering cane varieties as feed for his animals. It may be mentioned that although the female parent, POJ 2878, is an early and profusely flowering variety of sugar cane, the male parent, P.S.A. 14, seldom arrows and, if at all, only

very slightly. In fact it is classified as a non-arrowing variety. Apparently, the seedlings inherited these characteristics of P.S.A. 14. It is also likely that none of the seedlings produced flowers because they were transplanted late in June, 1946, or about five months after the sowing of the seeds in the seed bed.

Field data

Variability and habit of growth, color of stalks, position of leaves, and shape and prominence of buds. A summary of field observations and records on the habit of growth, color of stalks, position and persistence of leaves, presence of hairs on leaves, shape and prominence of buds, and presence or absence of growth and cork cracks of (POJ 2878 × P.S.A. 14) F_1 supposedly hybrid seedlings is presented below:

HABIT OF GROWTH	NO. OF SEEDLINGS	PERCENTAGE
Open	60	28.8
Close	148	71.2
Erect	156	75.1
Reclining	40	19.2
Lodging	12	5.7
COLOR OF STALKS		
Light green	59	28.3
Yellowish green	94	45.0
Purple	34	16.3
Yellow	21	10.0
POSITION AND PERSISTENCE OF LEAVES		
Upright	9	4.4
Bending	199	95.6
Persistent	138	66.4
Deciduous	70	33.6
PRESENCE OF HAIRS ON LEAVES		
Present	13	6.3
Absent	195	93.7
PRESENCE OF BUDS		
Nonprominent	66	31.7
Prominent and rounded	80	38.5
Prominent and pointed	62	29.8
PRESENCE OF GROWTH AND CORK CRACKS		
Growth and cork cracks	57	27.7
Growth cracks	12	5.6
Cork cracks	52	25.0
Without cork and growth crack	87	41.7

Habit of growth. There were more seedlings with closed stools than those with open ones. Likewise, most of the seedlings had erect or upright

habit of growth and only a few had lodging characteristics. Figure 1*a* shows a typical stool of seedling number 36 with close and erect habit of growth; figure 1*d* seedling number 123, representing seedlings with lodging characteristics. It is evident from this data that most of the seedlings

Fig. 1. Sugar-cane seedlings: *a*. No. 36 showing erect or upright growth; *b*. No. 29 with bending and persistent leaves; *c*. No. 12 with self-trashing or deciduous leaves, and *d*. No. 123 showing the lodging habit of growth. Photographs by the junior author.

inherited the close stooling characteristics of P.S.A. 14. Of the 208 cane seedlings studied, 156, or 75.1 per cent, had upright or erect habit of growth and only 12, or 5.6 per cent, had lodging stalks; the rest had reclining stalks. Evidently, a great majority of the seedlings inherited

this important agronomical characteristic of the parent varieties. Both parents, POJ 2878 and P.S.A. 14, have upright or erect habit of growth. The presence of a minimum number of seedling plants with lodging stalks is an advantageous characteristic of the cane seedlings studied and is an encouraging aspect of the study. In commercial sugar cane production, upright canes are preferred to lodging ones because they are easier to harvest and are less susceptible to the attack of pests, particularly rats. They would also be promising from the standpoint of farm mechanization.

Color of stalks. In color of stalk, the yellowish green predominated over the light green, the purple, and the yellow. This observation shows that more hybrid seedlings acquired the color combination of the hybrid varieties than inherited the color of either parents. It will be recalled that the stalks of P.S.A. 14, the male parent, are light green and become purple when exposed to light. Those of POJ 2878, the female parent, are greenish white and turn yellowish white when mature.

Position and persistence of leaves. With regard to the position and persistence of leaves, a great majority of the cane seedlings produced bending and persistent leaves. Figure 1*b* shows a typical seedling plant, No. 29, which illustrates this characteristic of these particular seedling canes. There were very few seedlings which had upright leaves and deciduous or self-trashing characteristics. Figure 1*c* shows a typical seedling plant (number 12) with upright leaves and deciduous or self-trashing characteristics. Self-trashing is a merit of commercial canes. The variety having this character is easier to harvest than one with persistent leaves, for in the case of the latter variety additional labor is required in removing the trash during the harvesting.

Presence of hairs on leaves and prominence of buds. The majority of the plants had no hairs on their leaves. There were more seedlings which had prominent and rounded, and pointed buds. This is a character inherited from POJ 2878, the mother plant. The production of prominent buds is a desirable characteristic of the seedlings, for it insures a greater rate of germination.

Growth or cork cracks. The absence of growth or cork cracks in the majority of the seedlings is also a significant feature. Both parent varieties do not have growth or cork cracks. In cane seedlings where cork cracks and growth cracks were observed, it was noted that cork cracks were more common than growth cracks. The absence of cracks is a desirable character, for cracks serve as avenues for pests and parasites.

Variability in presence of diseases and pests. A summary of the data on diseases observed in the cane seedlings follows:

Total number of hills studied	208			
Disease-free plants	71	hills,	34.16	per cent
Plants affected by				
Rust	44	"	21.15	" "
Banded sclerotial disease	102	"	49.03	" "
Pokkahboeng disease	10	"	4.80	" "
Leaf spot				
Very slightly	24	"	11.53	" "
Slightly	27	"	12.98	" "
Badly	38	"	18.26	" "
Very badly	48	"	23.07	" "

There were cases where a seedling cane was infected with more than one disease. The most prevalent disease observed was the banded sclerotial disease caused by *Rhizoctonia solani* Khün, which was present in a total of 102 seedling canes, or 49.03 per cent of the total number of hybrid seedlings included in the study. The effect of this disease, however, is not serious, for only the leaf sheaths were attacked. The other diseases, together with their incidence were rusts caused by *Puccinia kuehnii* (Kr.) Butl., 21.15 per cent, and the Pokkahboeng disease caused by *Fusarium moniliforme* Sheldon, 4.8 per cent. Yellow spot caused by *Cercospora kopkei* Kr. was prevalent in varying degrees of infestation. There were 48 seedling canes which were observed to be very badly affected with the yellow spot. It is worthy to note that in spite of the presence of these diseases in varying degrees in some cane seedlings, there were 71 seedling hybrids, or 34.16 per cent, which were apparently free from disease infection. With regard to insect pests, there were few insects observed in the culture. It was noted that 3 per cent of the total cane seedlings studied were attacked by "tamasoc," or gray borer of sugar cane *Olethreutes schistaceana* (Snellen). Another pest that was occasionally observed in some of the cane seedlings was the mealy bug, *Trionymus sacchari* (Cockerell). As a whole, the damage caused by these insects was negligible.

Variability and number of millable and nonmillable stalks, diameter, length of internode, height and weight of millable stalks. Table 1 shows the means and corresponding coefficients of variation of the different characters studied. It will be noted that with the coefficient of variability as an index of variation, weight of stalks was the most variable, with 51.01 per cent, and diameter of millable stalk, the least, with 17.6 per cent.

As a whole the results obtained in this study corroborate the findings of Morales (1928), who reported that a high degree of variability

in the weight of stalks, average diameter of stalks, length of internode, and number of millable and nonmillable stalks of each stool was obtained from hybrids and naturally selfed seedlings.

Selection of promising seedling. Since none of these hybrid seedlings were infected with a major disease, selection was made on the basis of the mean values for the total weight of the stalks of each seedling cane, number of millable stalks, height, diameter, and length of internode of millable stalks. Special emphasis was given to the weight of stalks. The seedlings which gave a mean weight of millable stalks more than the mean of all the seedlings were selected. Out of a total of 208 hybrid seedlings studied, 98, or 47.11 per cent, gave a mean weight of stalks higher than the mean yield of all the undamaged cane seedlings studied. Those that gave a mean weight of millable stalks less than the mean of all the undamaged seedlings were 110, or 52.89 per cent, which were discarded.

SUMMARY

1. The materials used in this study were 208 (POJ 2878 × P.S.A. 14) F_1 cane seedlings produced in the 1945–1946 arrowing season.

2. A great variation in the following characters of agronomic importance was noted: habit of growth, color of stalk, position and persistence of leaves, hairs on leaves, shape and prominence of buds, and presence of cork and growth cracks.

3. Some seedlings were infected with minor diseases, but no major disease was noted. Some apparently disease-free plants were found among the hybrids. Only a few were attacked by pests.

4. A higher degree of variability in weight of stalks, height and diameter of stalks, length of internode of millable stalks, and number of millable and nonmillable stalks to a seedling was observed among the supposedly hybrid seedlings. Variation among these characters was greatest in weight of millable stalks, with a coefficient of variation of 51.01 per cent, and lowest in diameter of stalks, with 17.6 per cent.

5. From among a total of 208 seedlings, 98, or 47.11 per cent, were selected, and 110, or 52.89 per cent, were discarded.

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TABLE 1

The means and coefficients of variation of the weight of stalks, number of millable stalks per stool, height of millable stalks, diameter of millable stalks, and length of internode of millable stalks

ITEM	MEAN	COEFFICIENT OF VARIATION
		per cent
Weight of stalks (kgm.)	6.69∓0.23	51.01
Number of millable stalks	9.55∓0.26	39.55
Diameter of millable stalks (cm.)	2.13∓0.01	17.60
Height of millable stalks (cm.)	171.90∓1.01	25.86
Length of internode of millable stalks (cm.)	13.70∓0.01	19.85

A STUDY OF ECONOMIC AND SOCIAL CONDITIONS IN A FARM VILLAGE OF LAGUNA[1]

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The first of a series of studies of conditions in Philippine farm villages appeared in 1940.[2] The primary aim of the studies is to secure a more accurate knowledge of the conditions, problems, and needs of farm villages as a basis for formulating an effective program of rural improvement.

The principal objects of this investigation, which was conducted in the barrio of Tranca, in the municipality of Bay, Laguna province, were to study (*a*) economic conditions, such as type of farming, size of farms, crops grown, livestock raised, farm practices, and farm income, and (*b*) social conditions, such as size of household, nature of dwelling, household facilities and conveniences, homeground beautification, educational facilities, school attendance, educational attainment, and organizational membership. The field survey was done largely in April, May, and June, 1939, and the data on farm business covered the preceding year ending April 30, 1939.

MATERIALS AND METHODS

The study included the 115 homes in the barrio. The survey method was employed in the investigation. A survey form prepared in the Department of Agricultural Education was used in collecting and recording the data. The information was obtained largely from the husbands and wives and older children.

RESULTS AND DISCUSSION

Description of the area surveyed

The barrio of Tranca is in the southeastern part of the municipality of Bay in the province of Laguna. It is about six kilometers from the poblacion, or town proper. The barrio is bounded on the east and west by creeks, on the north by the Manila Railroad line, and on the south by another barrio. The railroad maintains a station in the northern end of the barrio. A rough trail about three meters wide serves as the barrio road.

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[1]Experiment Station contribution No. 1458.

[2]SACAY, FRANCISCO M., AND FLORENDO R. NAANEP. 1940. A study of farm, home, and community conditions in a farm village of Ilocos Norte as a basis for formulating a program of rural education. The Philippine Agriculturist **29**: 555-570.

There is a road connecting the barrio to the poblacion. The village can also be reached from the neighboring town of Calauan by means of a second-class road. The other adjacent towns of Alaminos and Santo Tomas are connected to the barrio by trails which are passable only by pedestrians and horses.

Tranca is a fairly level plain, except for slight undulations at the southern extremity. The soil is Lipa clay loam. The climate has a distinct dry and wet season, but the dry season lasts only about four months, from January to April.

The people sell a portion of their products in the vicinity of the Masaya railroad station. The rest are sold in the town of Bay and in the neighboring towns of Alaminos, San Pablo, and Los Baños.

Within the barrio itself, there is only one store, which sells important household necessities, such as salt, laundry soap, and cigarettes. Near the Masaya railroad station, which is about two kilometers from the center of the barrio, are stores which serve the village people. There is a barrio school offering complete primary instruction. At the northern end of the barrio is a Roman Catholic chapel under coconut trees.

Population

The resident population of the barrio numbered 554 persons, of whom 51.3 per cent were males. Of the 115 heads of households, 106 were males and 9 were females.

Occupation. Farming was the principal occupation of the people. Of the household heads, 87.8 per cent were engaged in farming and only 12.2 per cent were in other occupations. Those in the latter group were engaged in cutting sugar cane, buying and selling coconuts, dressmaking, carpentering, teaching, driving cars, and drying copra.

Mobility. Many of the residents were not born in the barrio. Of the husbands, only 13.4 per cent were born in the barrio. A large proportion, 54.5 per cent, were born in bordering towns. More than three-fourths, 78.6 per cent, were born in the province of Laguna. In the case of wives, 25.0 per cent were born in the barrio, and 42.0 per cent in bordering towns. About 19.6 per cent were born outside the province.

The average age of household heads was 41.2 years. They had resided in the barrio for an average of 19.4 years. The length of residence in the barrio of 20.8 per cent was less than 10 years. The length of residence in the barrio according to tenure was: owner, 23.3 years; part-owner, 21.7; and tenant, 15.6 years.

Farm conditions

Farm ownership. Of the 101 heads of households engaged in farming, only 17.8 per cent were operating their own farms, which were mostly coconut plantations and orchards. About 50.5 per cent owned land and, in addition, rented areas from the Bureau of Forestry or worked on lowland rice fields owned by landlords. The number of farmers who were entirely landless or owned only their house lots was 32, or 31.7 per cent.

Type of farm. The dominant types of farms are rice-sugar cane, 27.7 per cent, and rice, 24.7 per cent. General farms comprise 13.9 per cent and coconut, 10.9 per cent. The other types are sugar cane, coconut-lanzones, coconut-banana, and rice-corn. The barrio is a good example of places in the Philippines where climatic and soil conditions permit a diversified type of agriculture. In Tranca, only 44.5 per cent of the farms are specialized, that is, getting the major portion of the income from one enterprise.

Investment and ownership of capital. The average capital invested per farm was ₱1,454.94. The greater portion was in land, 82.5 per cent; buildings, 8.2 per cent; and work animals, 5.2 per cent.

The farm operators owned the various items of farm property, except land, of which the operators owned only 45.4 per cent of the amount invested. Of the total amount invested in the farms studied, 54.9 per cent belonged to the farm operators.

The amount invested by the operators according to tenure was: owner, ₱1,576.40; part-owner, ₱916.38; and tenant, ₱174.52.

Size of farm. The farms ranged from less than one half to 20 hectares, or an average of 3.96 hectares for the entire group. About 40 per cent of the farms were less than 3 hectares in size. The size of farms according to tenure was: owner, 4.48; part-owner, 4.52; and tenant, 2.89 hectares.

The farm area was utilized as follows: crops, 86.4 per cent; orchard, 12.6; and farmstead, including home orchard, 1.0 per cent.

Crops grown and livestock raised. Of the 101 farmers, 83.2 per cent grew rice and cultivated an average area of 1.34 hectares. Sugar cane was grown by 47.5 per cent, and the average area devoted to it was 0.94 hectare. The next important crop was coconut, which was grown by 68.3 per cent on an average area of 0.85 hectare. A large proportion of the farmers also raised corn, vegetables, and fruits, such as lanzones and bananas. The average farmer had a crop area of 3.92 hectares.

The principal livestock raised were carabaos, chickens, and swine. There were very few cattle, horses, geese, and goats. The average number of animals raised per farm was: carabaos, 1.1; hens, 3.6; and swine, 1.5.

Farm receipts and expenses. The farm receipts per farm amounted to ₱185.53, excluding the value of products used at home. The sales of farm crops, which were mostly coconuts and sugar cane, amounted to ₱119.94, or 64.7 per cent of the total receipts. Receipts from fruits, mostly lanzones and bananas, averaged ₱38.48, or 16.2 per cent. Livestock contributed 9.2 per cent, and vegetables, 0.4 per cent to the farm receipts.

The farm receipts according to tenure were: owner, ₱202.05; part-owner, ₱222.69; and tenant, ₱116.99.

The average farm expenses amounted to ₱116.16. The highest item was land rent, amounting to ₱46.44, or 39.9 per cent of the total. The proportion was high because a large number of farm operators did not own the land that they cultivated. Cash expenses comprised 34.6 per cent, and unpaid family labor, 16.2 per cent.

The farm expenses according to tenure were: owner, ₱66.64; part-owner, ₱146.68; and tenant, ₱95.39. The owners had relatively smaller expenses because they had no land rent to pay.

Labor income. The labor income averaged ₱13.44. This low figure was partly due to the fact that a high proportion of farm products was not sold but was used at home. The labor income of owners was ₱25; part-owners, ₱11.86; and tenants, ₱9.38.

Farm privileges. The value of products used at home amounted to ₱68 per farm, or 29.0 per cent of all products produced. About 32.6 per cent of crops, 20.3 per cent of vegetables and fruits, and 12.6 per cent of livestock products were used at home. In addition to farm products, the farm also furnished the family a house to live in. The average value of these privileges was ₱82.11 per farm. The largest portion, 70.7 per cent, consisted of crop products.

The farm privileges of different classes of operators were: owner, ₱54.57; part-owner, ₱96; and tenant, ₱75.49.

Operator's labor earnings. The operator's labor earnings include the value of farm privileges. In many regions of the Philippines where a large proportion of products is used at home, the labor earnings are a better measure of the financial success of the farming business. The operator's labor earnings averaged ₱95.55. The owner made ₱79.63; the part-owner, ₱107.87; and the tenant, ₱84.87.

Family income. The average family income per farm was ₱171.60. Of this amount, only 55.7 per cent consisted of the operator's labor earnings from the farm. The operator and his family secured income from other sources. The operator, by working on other jobs, earned ₱24.31, or 14.2 per cent of the family income. His total contribution amounted to 69.9

per cent; that of the other members, 28.2 per cent. Very little aid was received by the family from children staying away from home.

The family income of the owner was ₱137.46; part-owner, ₱189.89; and tenant, ₱161.89. These amounts did not include the interest on capital, which was charged as expense. The interest earned by farm capital averaged ₱110.35 for owners, ₱64.15 for part-owners, and ₱12.22 for tenants, or an average of ₱55.19 per farm. When this amount was added to the family income, the amount available for family living averaged ₱226.79. The owner had ₱247.81; the part-owner, ₱254.04, the tenant, ₱174.11. The amount available per adult male equivalent was ₱69.80 for owners, ₱60.48 for part-owners, and ₱45.70 for tenants, or an average of ₱57.27. It was found that as the size of the household increased, the operator's labor earnings per adult, family income per adult, and amount for family living per adult equivalent generally decreased.

Farming practices. The farm operators did not employ improved farm practices. In the culture of rice, the farmers did not apply manure or commercial fertilizer, use green manure, control pests and diseases, nor keep accounting records. About 70 per cent, however, selected seeds for planting, and 1 per cent practiced crop rotation with legumes. In the growing of coconut, primitive methods were employed. About 42 per cent of sugar cane growers applied manure and commercial fertilizers at the landlord's suggestion.

Practices in connection with livestock raising were also backward. In poultry raising, no farmer fed balanced ration, caponized, used improved stock for upgrading, or controlled pests and diseases by quarantine, disinfection, or medication. Only 25 per cent provided poultry houses. In swine production, 70 per cent selected the stock and 10 per cent used improved stock for upgrading. Other desirable practices were not employed.

Home conditions

Type and size of households. Of the different types of households, husband-wife comprised 3.5 per cent; husband-wife-children, 48.7 per cent; husband-wife-children-relatives, 24.3 per cent; and broken families, 11.3 per cent.

The number of persons in the household ranged from 1 to 10. About 87 per cent had from 3 to 7 individuals. The average household contained 1.83 parents, 2.29 children, 0.65 relatives, and 0.03 others, or a total of 4.80 persons.

Nature and size of dwellings. About 74 per cent of the dwellings had iron roofing; the remainder had roofs made of cogon. The most common type of dwelling, consisting of 35.6 per cent, had iron roofing, bamboo walls,

and bamboo floors. About 25 per cent had also iron roofs, but with wooden walls and bamboo floors. Houses with walls of coconut leaves comprised 11 per cent. These had roofs made of cogon.

The average value of dwellings was ₱111.83. About 62 per cent of the dwellings were valued at ₱99 or less, whereas only 5 per cent were valued at ₱300 or more. No dwelling exceeded ₱600 in value. The owners had much better houses than the tenants.

The floor area of the dwellings averaged 31.37 square meters, or 5.71 square meters per person. There were 2.5 rooms per dwelling, or 1.9 persons per room. Forty-six per cent of the dwellings had two rooms and 31 per cent had 3 rooms each.

Household facilities and conveniences. The homes had limited facilities, and conveniences. No home had any of the following: ice box, water pump, running water, electric light, gas stove, indoor toilet, outdoor sanitary toilet, phonograph, piano, or radio. The items commonly found were: bamboo beds, 4.3 per cent; wooden beds, 3.4; iron beds, 1.7; sewing machines, 13.0; wooden benches, 48.7; wooden chairs, 8.5; iron chairs, 4.3; and water container with faucet, 73.9 per cent.

Homeground beautification. Some farm dwellers made attempts to beautify their homes and yards. The following were found: fenced farmstead, 4.3 per cent; raised walk leading to stairs 2.6; plants along walk leading to stairs, 18.3; hedges on front boundary, 70.4; hedges on side boundaries, 65.2; hedges around dwelling, 1.7; potted plants in house, 9.6; hanging plants in house, 20.0; beds of ornamental plants, 1.7; framed pictures in house, 66.1; mirrors, 69.6; door curtains, 0.9; and window curtains, 1.7 per cent. About 87.8 per cent had banana plants on the farmstead and 49.6 had fruit trees other than bananas.

Community conditions

Educational facilities. There was a schoolhouse made of strong materials in the barrio. The enrollment in the four grades was 103. There were two teachers.

School attendance. There were 90 children 7 to 14 years old in the barrio. Of this number, 51.1 per cent were not in school. These children completed an average of 2.6 grades.

Of the 75 children 15 to 24 years of age, only 2.7 per cent were in school, and 97.3 per cent had left school. The average grade completed by this group was 3.5.

Reading matter in the home. The majority of the homes, 72.2 per cent, had only one book each, exclusive of school textbooks. In 18.3 per cent of

the homes, there were no books; there were two in 6.9 per cent; and 3 in 2.6 per cent. The average number of books per home was 1.1.

Current literature was found in few homes. *Liwayway*, the most popular Tagalog weekly magazine, was found in 29.6 per cent of the homes, but only 0.9 per cent of the families were regular subscribers. The others borrowed their copies or bought copies occasionally. The other publications found were: *Hiwaga*, 3.6 per cent; *Sakdal*, mouthpiece of a radical political organization, 2.6; *Taliba*, 2.6; *Sunday Tribune*, 0.9; *Mabuhay*, 0.9; and *Song Movies*, 0.9 per cent. No farm journals, farmers' bulletins, or circulars were found.

Only six homes in the barrio were regular subscribers to current literature, as follows: *Sakdal*, 2.6 per cent; *Sunday Tribune*, 0.9; *Taliba*, 0.9; and *Liwayway*, 0.9 per cent.

Organizational membership. Only 23.5 per cent of the families were represented in organizations, which were either political or religious. There were no organizations to promote farming or other economic activities.

SUMMARY OF FINDINGS

1. A survey of farm, home, and community conditions in the barrio of Tranca, Bay, Laguna, showed that farming was the occupation of 87.8 per cent of household heads. Of the farm operators, 17.8 per cent were owners, 50.5 per cent were part-owners, and 31.7 per cent were tenants.

2. The principal types of farming were: rice-sugar cane, 27.7 per cent; rice, 24.7; coconut, 10.9; coconut-lanzones, 8.9; sugar cane, 8.9; and general, 13.9 per cent.

3. The average investment per farm was ₱1,454.94, of which 54.9 per cent belonged to the farm operator.

4. The principal crops grown were rice, sugar cane, coconut, and corn. The principal livestock raised were carabao, swine, and poultry. The farmers generally employed primitive methods of farming.

5. The farm receipts per farm averaged ₱185.53; farm expenses, ₱116.16; labor income, ₱13.44; farm privileges, ₱82.11; operator's labor earnings, ₱95.55; operator's total income, ₱119.86; and family income, ₱171.60. The amount available for family living was ₱216.81 per household, or ₱54.75 per adult male equivalent.

6. Of the different types of households, the husband-wife-children comprised 48.7 per cent, and husband-wife-children-relatives, 24.3 per cent. The average household consisted of 1.83 parents, 2.29 children, and 0.58 others, or 4.80 persons.

7. Only 13.4 per cent of the male households were born in the barrio. Household heads had resided in the barrio for 19.4 years.

8. The majority, 73.9 per cent, of the houses had iron roofing. The rest had cogon roofs. Houses with iron roof, bamboo walls, and bamboo floor comprised 35.6 per cent; those with iron roof, wooden walls, and bamboo floor, 25.2 per cent. The average value of dwellings was ₱111.83. Each had 2.5 rooms, or 0.5 room per person. Household conveniences were meagre.

9. Of children 7 to 14 years old, 51.1 per cent were not attending school; of those aged 15 to 24 years, 97.3 per cent. The average grade completed by the latter group was 3.5.

10. The number of books per household was 1.1. Although current literature was found in several houses, only 5.1 per cent were regular subscribers.

THE EFFECTS OF THE ADDITION OF COPRA MEAL TO LOS BAÑOS CLAY LOAM[1]

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Although extensive work has been done on the feeding value of copra meal, there is no literature bearing on its fertilizing value. Because of its chemical nature, the fertilizing value of copra meal can be evaluated only after it has been decomposed. Since the rate of decomposition of organic fertilizers is influenced by soil, climatic conditions, and rate of application, it is important that a study of the length of time of decomposition of copra meal and its rate of application to Los Baños clay loam be made; hence, this work was undertaken in the Department of Soils from May, 1946, to February, 1947. The objects of the work were: (*a*) to determine the effects of adding copra meal to Los Baños clay loam with lettuce as an indicator; (*b*) to compare the residual effects of copra meal with those of ammonium sulfate, and (*c*) to determine the length of time that should be allowed for copra meal to decompose and the best rate of application.

REVIEW OF LITERATURE

Literature on the fertilizing value of copra meal, especially under Philippine climatic conditions is wanting. Many reports, however, are available on the protein content of copra meal. Lindsey (1914), in his feeding experiments on dairy cattle, reported that copra meal contains 19.35 per cent protein. Santos (1920) analyzed copra meal and found the following: moisture, 13.3 per cent; oil, 12.2 per cent; crude protein, 20.1 per cent; ash, 5.5 per cent; crude fiber, 13.2 per cent; and carbohydrates, 37.0 per cent. In his analysis of copra meal, Caray (1921) found that it contains 20.94 per cent protein. According to Galvez *et al* (1928), Jaojoco found that copra cake contains 19.9 per cent P_2O_5 and 8.14 per cent K_2O. In a report on the proximate chemical analysis of Philippine foods, Adriano (1925) stated that copra meal from the Philippine Refining Company contains 19.62 per cent protein. Sulit (1926) stated that Fingerling (1909), Skelton (1911), Cranfield (1912), Carlier (1913), and Ewing and Spence (1918) found copra meal to be an efficient source of protein concentrate. Galvez *et al* (1928) reported that copra meal contains 17 to 18 per cent protein.

[1]Experiment Station contribution No. 1459. Prepared in the Department of Soils under the direction of Assistant Professors N. L. Galvez and D. I. Aquino.

Because of its composition, copra meal may serve as a good organic fertilizer for Philippine soils. It is known that in most cases the infertility of soils in warm places is due to the lack of nitrogen and organic matter.

MATERIALS AND METHODS

Materials

Los Baños clay loam, medium phase, taken from the soil in front of the former farmstead house of the U.P. Rural High School, was used in this experiment. The area from where the soil was taken is slightly rolling and had been planted to sweet potatoes which showed fair growth. The surface soil is reddish-brown and about 17.0 cm. (7 inches) deep. It is moderately compact and pulverizes easily when dry. When wet, it is sticky and plastic. According to Aristorenas (1937), the surface soil of Los Baños clay loam, medium phase, has a maximum water-holding capacity of 62 per cent, a specific gravity of 1.27, pore space of 61 per cent, pH of 7.38, and contains 0.06 per cent K_2O. Aquino and Orig (1941) reported that this soil type contains 0.0107 per cent P_2O_5, 0.0313 per cent K_2O soluble in 1 per cent citric acid, and 0.0031 per cent nitrogen.

The copra meal used in this study was an expeller product purchased by the Department of Animal Husbandry, College of Agriculture, in San Pablo, Laguna. Sulit (1926), who analyzed copra meal which was an expeller product from the oil mills of San Pablo, Laguna, obtained the following results: 15.21 per cent moisture, 19.91 per cent fats and oils, 5.57 per cent ash, 16.53 per cent protein, 12.52 per cent crude fiber, and 34.26 per cent carbohydrates. The copra meal was ground in a feed grinder before it was used.

Seedlings of lettuce of the same age and apparently of the same size and vigor were used as indicators of the fertility of the soil.

One hundred and ten one-gallon tin cans, each with a diameter of 15 centimeters and a height of 18 centimeters, were used as pots. They were perforated at the bottom and painted with coal tar to prevent them from rusting rapidly.

Thermometers calibrated in centigrade were used in getting the daily temperature changes due to decomposition.

Methods

The soil was dried in the air, pulverized, screened through a 7 mm.-sieve, and then thoroughly mixed. One hundred and ten cans were each filled with soil and treated as follows: the soil in each of the first ten cans was mixed with 100 grams of copra meal, wet with 600 ml. water equivalent to

about 60 per cent of the water-holding capacity of the mixture, and then allowed to decompose. The daily temperature changes were noted. One week later, the second ten pots were treated in a similar manner. Seven other groups of ten pots each were likewise prepared at intervals of one week, and as usual, the corresponding daily temperature changes were noted. The ninth set, however, had not undergone decomposition when, together with the other pots, it was planted to lettuce seedlings on the ninth week. In order to prevent the ants from carrying away the copra meal, the pots were placed on a table, the legs of which stood in cans filled with water. Before planting, the mixtures were remixed once every 4 days for 16 days.

All the pots were given the same care and the same amount of water. Observation with regard to the plants' susceptibility to insect pests and diseases was also made. The best-looking plants in each lot were photographed.

The plants were harvested by cutting the base with a sharp knife; then they were weighed. On November 1, 1946, seven days after the lettuce plants were harvested, the roots left in the cans were removed. All the cans were placed in the shade to prevent as much as possible the loss of plant nutrients by leaching due to heavy rain.

On November 3, 1946, nine days after the plants were harvested, the soil in each can was broken to loosen it. A second planting was made to study the residual effects of the different treatments with lettuce plants again as indicators. The same variety of lettuce plants of the same age and apparently of uniform size and vigor as those used in the first planting was used. The nature of growth and the susceptibility of the plants to insect pests and diseases were again observed. Again, the best plants were photographed before they were harvested.

The second part of the experiment was the determination of the rate of application of copra meal and of that of ammonium sulfate best suited to the plant used as indicator. The soil media for the different lots were mixed at the same time and allowed to age for the same length of time as found best in the first part of the experiment. This time each treatment was carried out in only five replications. The eight copra meal lots, namely I, II, III, IV, V, VI, VII, and VIII, received 200, 150, 100, 50, 25, 12.5, 6.3, and 3.2 grams per pot, and the corresponding ammonium sulfate lots received 26.4, 19.8, 13.2, 6.6, 3.3, 1.65, 0.8, and 0.4 per can.

All the cans, including those of the control lot, were planted at the same time to lettuce seedlings of apparently the same size and vigor. They were exposed to outside conditions and given the same care. Observations of the growth of the plants and their susceptibility to insect pests and

diseases were made. Plants from the different lots were made into salad which was served to a group of students whose opinions regarding its taste and palatability were noted.

RESULTS

After copra meal mixed with the soil had been more or less completely decomposed, the soil became darker brown, more friable, porous, and easier to work than that of the control lot. The porosity of the soil increased as shown by the rapid percolation of water added. This observation is in conformity with the findings of Norman (1943) that "the organic matter has physical functions, in that some of its properties, such as moisture-holding capacity and volume weight, are of such a different order than those of the inorganic constituents that the presence of a few per cent of organic matter has an entirely disproportionate leavening effect on the soil as a whole."

The plants in lot IX, which contained a fresh mixture of soil and copra meal, were the slowest to recover from the effects of planting, while the plants in the other lots showed complete recovery from the effects of planting almost at the same time and very much earlier than those in lot IX. With the exception of those in lot IX, all the plants in the other lots showed no difference in the color of the leaves and in the rate of growth of the plants during the first week. After the second week, however, marked differences in the color of the leaves and in the size of the plants were noticeable. In general, the plants in the same lot were more or less the same in regard to color of leaves and size of plants. Selected on the basis of size and vigor of the plants, lots V, IV, and III, ranked in the descending order, were the best. The plants in lot IX, where the mixture of soil and copra meal was made at the time of planting, were the poorest, and the plants in lot XI (the control), the second poorest. On the third week, the lots found to be the best, based on the same criterion, were lots VIII, VII, and VI. Of these three, lot VIII seemed to be the best. In all cases, all the plants in the treated lots were better than those in the control lot. On the fourth week, the plants in lots VIII, VII, and V seemed to be the best. It was also observed that the leaves of the plants in the lots containing mixtures of soil and copra meal were very much larger, more tender, and darker green than those in the control lot (XI) and those in lot X, which received ammonium sulfate treatment.

No plant was attacked by insect pests and diseases.

There was a concurrence of opinion regarding the taste and palatability of the different samples served to the students. The plants from lot

IX were considered to have the most wholesome taste and to be the most palatable. The leaves of these plants were also the greenest, the most succulent, and the most tender as compared with the leaves of plants from the other lots. The plants from lot XI (control) produced crisp leaves which gave a slightly bitter taste. The leaves of the plants from the lot treated with ammonium sulfate had crisp leaves with a very bitter taste. This seems to be in consonance with the remarks of some people that lettuce plants fertilized with ammonium sulfate taste bitter.

The growth and appearance of the plants in the second planting were in conformity with their weights.

The decomposition of 100 grams of copra meal mixed with 4.8 kilograms of soil started on the first day after the mixtures were set. On the third day the rate increased rapidly until the eleventh day, after which the rate of decomposition slowed down gradually until the temperature readings were almost the same as those of the control lot.

With the exception of lot IX, all lots containing the same amount of copra meal, which was allowed to decompose for different lengths of time, gave varying but consistently higher yields than the lot treated with ammonium sulfate fertilizer. This points out the fact that the length of time of decomposition of copra meal affects the yields of lettuce plants. This means also that the nitrogen in the copra meal in lot IX, which was not allowed to decompose before planting, was not so readily available as it was in the other treated lots, and that copra meal had not imparted its beneficial influence to the soil. This explains why fresh organic fertilizer is not commonly used.

With the exception of lot IX, which contained a fresh mixture of soil and copra meal, the trend of results showed that the weights of lettuce plants in the first experiment decreased as the length of time of decomposition increased. This would bring forth the fact that copra meal as a fertilizer should be used judiciously. Improper use, one way or the other, may result in adverse effects. If it is allowed to decompose for a long time, its fertilizing value may be lost before it can be utilized; and, if it is not given enough time to decompose, the plants may suffer from harmful effects.

The comparative residual effects of copra meal and of ammonium sulfate in the different lots in the first experiment show that lot IX, which had the lowest yield among the lots treated with copra meal in the first planting, gave the highest yield of lettuce plants in the second planting. This shows that in the first planting, the plant nutrients contained in the fresh mixture of soil and copra meal were not yet completely available to the plants. This corroborates the findings in the first planting that the

lot in which the copra meal was not decomposed before planting gave the lowest yield.

The results of the analysis of variance show a highly significant F-value of 8.59. This means that the variation of the residual effects of the different lots, as indicated by the weights of lettuce plants, is due to the different duration of decomposition of the copra meal added to the Los Baños clay loam. The observation that weights of lettuce plants decrease as the length of time of decomposition increases is (with the exception of lot IX) fully supported by the results of the second planting. This time, the lot containing a fresh mixture of soil and copra meal gave the highest yield.

The results of the first and the second plantings prove that copra meal is much better than ammonium sulfate for improving the fertility of Los Baños clay loam.

The best rate of application of copra meal when allowed to decompose for one week is 100 grams a pot and that of ammonium sulfate, 0.4 gram. This statement is supported by the results of the analysis of variance of the lettuce plants. A highly significant F-value of 8.24 means that the variation in the yields of lettuce plants in the different lots is due to the difference in the amounts of copra meal added to the lots.

Lot VIII, which received 3 grams of copra meal in each can, gave almost the same yield of lettuce plants as lot XV, which was fertilized with 0.4 gram ammonium sulfate a can. Based on their nitrogen content, the two lots had the same amount of nitrogen, 0.08 gram., in each can. If the amount of nitrogen added is increased to 2.6 grams a can, the yield of lettuce plants grown in cans with copra meal is always higher than that of those in cans with ammonium sulfate. However, higher rates of either copra meal or ammonium sulfate fertilizer showed detrimental effects on the growth of the plants.

The response of Los Baños clay loam to the addition of copra meal and of ammonium sulfate indicates that copra meal, when added to Los Baños clay loam, showed better results than ammonium sulfate.

Copra meal improves not only the physical and chemical but also the biological properties of soil, which influence producing capacity.

SUMMARY OF CONCLUSIONS

1. Under the conditions prevailing during the experiment, copra-meal fertilizer added at the rate of 100 grams to every 4.8 kilograms of Los Baños clay loam is most effective when allowed to decompose for one week before the soil is planted to lettuce.

2. Undecomposed copra meal added at the rate of 100 grams to 4.8 kilograms of Los Baños clay loam affected the growth of lettuce seedlings unfavorably. After one week, however, it accelerated the growth of the plants. This means that copra meal must be given enough time to decompose before the soil with which it is mixed is planted to lettuce seedlings.

3. The best rate at which copra meal may be added to Los Baños clay loam and allowed to decompose for one week is 100 grams to 4.8 kilograms of soil.

4. The best rate of application of ammonium sulfate to Los Baños clay loam is about 0.4 gram to 4.8 kilograms of soil.

5. The effect of copra meal on Los Baños clay loam is decidedly better than that of ammonium sulfate, as indicated by the growth of the lettuce plants.

6. The residual effect of copra meal on Los Baños clay loam is better than that of ammonium sulfate, as indicated by the weights of the lettuce plants in the second harvest.

7. The lettuce plants grown in the lots to which copra meal had been added were more wholesome and more palatable than those grown in the lots fertilized with ammonium sulfate. In the latter the lettuce was tougher and tasted bitter.

8. The copra meal added to Los Baños clay loam made the soil dark brown, friable, porous, and easy to work.

9. The lettuce plants grown in the mixture of Los Baños clay loam and copra meal were bigger and more vigorous than those grown in the control or in the ammonium sulfate-treated lots.

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VARIABILITY OF PILI TREES GROWN IN THE COLLEGE OF AGRICULTURE[1]

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The pili, *Canarium ovatum* Engl., is one of our most important export nut fruits. Pili exports into the United States in 1936 amounted to 47,838 kg., valued at ₱9,896 (Silayan).[2]

The pili is a plant of many uses. All the parts of the fruit are utilized. The pulp is rich in oil and protein and is highly relished in the Bicol region where it contributes, whenever it is available, an important part in the meal of the average person. The shell is an excellent fuel. In Java, out of this hard covering are fashioned ornaments very popular among tourists. The tree is well-formed and makes a good avenue tree. It is one of the trees most resistant to strong wind. The wood is rich in resin, being one of the sources of Manila elemi, and makes good firewood. The young leaves are an excellent substitute for green paho, *Mangifera altissima* Blanco, in the preparation of Philippine salads or relishes.

Review of literature

Wester (1916) called attention to the probable existence of a paper-shelled pili in the Philippines.

Brill and Agcaoili (1910) analyzed the kernel and determined the constituents of the oil. Of particular importance was the information pointing to the high iodine value of the oil, which is from 186 to 192.

De Leon and Agdeppa (1939) found pilinut oil a good hardening mixture for coconut oil in the preparation of a cooking oil high in melting point.

Padilla and Soliven (1933) and Garcia (1941) made individual reports on the analysis of the kernel varying from 4.16 to 23.74 per cent moisture, 13.91 to 17.25 per cent protein, 75.14 to 78.55 per cent fats, 3.11 to 3.12 per cent ash, 1.86 per cent fiber, and 4.49 per cent carbohydrates. Likewise, Brown in 1941 included in his report the chemical composition and chemical constant of the pili oil. He called attention to the high culinary

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[1]Experiment Station contribution No. 1460. Portion of a thesis presented by the junior author for graduation, April, 1947, with the degree of Bachelor of Science in Agriculture.

[2]Silayan, H. S. 1940. Pili industry and U. S. trade. Plant Industry Digest **6**: 64-65. (Multigraphed).

value of the oil from the kernel which he classified sweet. He also reported that oil extracted from the pulp may be used for lighting as well as for cooking.

Juliano (1936) studied the stony layer in the fruit and found that the shell of the pili as a whole is carpellary in origin, its inner part (inner stony layer) arising from the innermost epidermal cells surrounding the loculi, and the thick outer part (outer stony layer) developing from the numerous hypodermal cells of the endocarp. He also found that in the germination of seeds, water enters the shell where the seed lies through the basal end of the shell, the thinnest part of the stony layer surrounding the functional locule.

Austria (1932) worked on the different methods of removing the husk of pili. He found that immersion in water from 10 to 15 minutes at 40° to 50°C. facilitated the softening and removal of the pulp, thus shortening the time for preparing the nut for the market. At this temperature there was no significant adverse effect on the keeping quality of the nut. When temperature above 70°C. was used, however, although the pulp softened faster, the nuts so prepared became rancid much sooner. On the other hand, retting in ordinary tap water at room temperature required from 24 to 72 hours before most of the nuts could be husked easily.

Cabrera[3] found that untreated seeds, that is, seeds with their shells unharmed or intact, gave the highest percentage of germination (71.8 per cent to 86.6 per cent as average), whereas the shelled seeds germinated the earliest.

Mercado (1924)[4] found the pulp of both *Canarium ovatum* and *C. commune* suitable for the preparation of "Chinese olives." While all stages of development of the fruit could be prepared first by brining and, later on, flavoring as with the commercial sweet pickles, the green stage, soon after the stone hardened but before the pulp became too fibrous, was the best.

The present study was made to record variability of plant and fruit characters in seedling pili trees grown in the College of Agriculture.

MATERIALS AND METHODS

The seedling pili trees used in this study were grown from seeds obtained in Oas, Albay, in 1919. Whether these seeds were from a single tree or not was not definitely ascertained. The seeds were germinated

[3]Cabrera, V. D. Some methods of propagation of pili, *Canarium ovatum* Engl. and *C. luzonicum* (Blm.) A. Gray. (Thesis presented for graduation, 1932, with the degree of Bachelor of Science in Agriculture. Unpublished).

[4]Mercado, Honesto. A study of the suitability of pili fruits for pickling purposes. (Thesis presented for graduation, 1942, with the degree of Bachelor of Science in Agriculture. Unpublished; manuscript burned).

and later transplanted in the mango and citrus orchards of the College, and along the Experiment Station road. They were planted at a distance of about 6 × 10 meters. A total of 95 surviving trees were studied. A meter stick, a balance, a bamboo pole for picking the fruit, and paper bags were used in gathering the necessary data.

RESULTS

Field observation of individual trees

Sex. The pili plants are predominantly dioecious. An outstanding feature observed is the presence of a great number of male or barren trees. Out of a total of 95 trees, 52, or 54.73 per cent, are female and 43, or 45.27 per cent, are male. This seems to point out the inadvisability of growing pili commercially from seeds.

Habit of growth. With regard to growth habit, the seedling trees that had upright growth were more than those with spreading habit. There seems to be no relationship between the growth habit of the trees and their sex, for almost 50 per cent of the male had upright growth and 50 per cent had spreading growth habits. Likewise, almost 50 per cent of the female had an upright, and 50 per cent, a spreading habit of growth.

Fruiting habit. The number of months the different trees were in fruit varied from two to nine. It is possible that those trees observed to bear fruit throughout the nine months covered in this study may bear throughout the year. There were six out of a total of 52 female trees (1.5 per cent) that exhibited this characteristic of the seedling trees. In the Bicol region, pili trees, as a rule, come into season only once a year, during the months of May and June. Since the planting material of the trees in the College came from a tree partly selected for frequency of bearing during the year, it is possible that this characteristic of the tree has been not only perpetuated but also intensified. Whichever factor is responsible, the ever-bearing characteristic or better adaptability to local conditions, or both, there is no gainsaying the desirability of growing these promising trees asexually in Los Baños or in any place of similar climatic condition.

Prolificness. The pili trees varied very much in their fruit-bearing capacity. Out of a total of 52 supposedly female trees, 29, or 56 per cent, were poor bearers and only five, or less than one per cent, were heavy yielders. These poor-bearing trees produced 500 fruits each, or less, and the heavy yielders gave each 2,001 to 3,435 fruits within the period covered in this study. This result again indicates that it is not a good venture to grow pili commercially from seeds.

Pomological study of pili in the laboratory

Shape of fruit and nut. As a whole, the shapes of the fruit and the nut of the same tree are similar. About 50 per cent of the trees produced elliptical fruit and nut. Those trees with oval fruit and nut formed about 36 per cent, about 10 per cent with oblong, and only one tree bore fruit and nut obovate in shape. The four types of fruit observed indicate that the pili trees under study were probably a mixture of four distinct strains.

Color of rind and of pulp. All of the trees studied produced fruit that had a black rind when ripe. Great variation was noted in the color of the pulp. The greatest number of trees bore fruit with cream-colored pulp and the second greatest had fruit with light buff pulp. A few of the other trees produced fruit whose pulp was any one of the following colors: massicot yellow, barium yellow, pale salmon yellow, pale chalcedony yellow, and straw yellow.

Eating quality of the pulp. In the Bicol region, the pulp of pili forms an important part in the diet, particularly in that of the poor people, and rightly so because of its high food value and its rich nutty flavor. On the basis of least fiber content, richness in taste, and attractiveness in color of the pulp, five trees were selected as the most desirable out of the forty-two female trees studied. In ranking, tree No. 94 was placed first; No. 30, second; No. 66, third; No. 9, fourth; and No. 8, fifth. Although tree No. 66 was recorded as "fibrous" without having its pulp passed through a sieve, which characteristic placed it third in the selection, difference in texture from the pulp of the fruit of the different trees was hardly noticeable.

Laboratory data on the fruit

Weight of fruit. The fruits of the different seedling trees varied in their weight as shown by the analysis of variance. The F-value, when trees are the source of variation, is 42.01, and the tabular value at 1 per cent level is 1.72; hence, the variation is highly significant. Tree No. 66, with a mean weight of 391.70 grams per 10 fruits, gave significantly the heaviest fruit. On the basis of this criterion of heaviest fruit, tree Nos. 30, 61, 28, 36, 46, 37, and 35 are second to No. 66, and their differences are insignificant. Only 17 trees, or 40.47 per cent, produced fruit significantly heavier than the mean weight of fruit of all the trees studied.

Weight of pulp. The variation in the weight of pulp of the different trees showed that tree No. 66 gave the significantly heaviest pulp. In general, trees having heavier fruit produced heavier pulp. Eighteen trees, or 42.85 per cent, produced fruit with pulp heavier than the mean weight of pulp produced by the different trees.

Weight of nut. There was a significant variation in the weight of nut of the different trees. A total of 12 trees, or 28.57 per cent, each produced nuts significantly heavier than the mean weight of the nuts of all the trees studied. As a whole, the trees that produced heavier fruit and pulp also produced heavier nuts.

Weight of edible kernel. Significant variation in the weight of the edible kernel of the fruit of the different trees was noted. A total of 14 trees or 33.33 per cent gave significantly heavier edible kernel than the other trees. Tree No. 63 had the heaviest edible kernel and tree No. 66, the second heaviest.

Variation constants of the different characters of the fruit. The variation constants of the weights of the fruit, pulp, nut, and edible kernel of the fruit of the different trees were recorded.

The weight of the edible kernel is the most variable, with 26.60 per cent variability; those of the fruit and the pulp ranked second with about 20 per cent each; and the weight of the nut, the least variable, with 17.58 per cent.

Selection of the most promising or valuable pili trees

The selection of the most promising or valuable pili seedling trees was based on the total number of fruit produced by each tree and on the qualities of the fruit as judged by the mean weights of the fruit, the nut, the pulp, and the edible kernel. Only two trees or 2.10 per cent of a total of 95 trees studied, or 3.84 per cent of the total 52 female trees recorded, qualified in the selection under all of the criteria mentioned. These two seedling trees, Nos. 66 and 74, were therefore selected. On the basis of eating quality of the pulp, tree No. 66 ranked third. For the choice of an all-around tree, undoubtedly tree No. 66 would rank the best among all the trees studied.

SUMMARY

1. The 95 pili trees studied were dioecious, the female being 54.73 per cent of the population, and the male, 45.27 per cent.

2. The trees varied greatly in season of fruiting, productiveness, and quality of fruit borne.

3. Six trees bore fruit during the nine months of study, and past observations indicate that they bear throughout the year.

4. Only trees Nos. 66 and 74 were finally selected on the basis of prolificness and quality of the fruit produced.

5. The variability of the pili trees was due to their sexual origin, the obligatory cross-pollination resulting from their dioecious habit.

6. Aside from bearing unisexual flowers, some promising trees may have borne perfect as well as female flowers; i.e., they showed a gynomonecious habit.

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CORRELATION BETWEEN WEIGHTS AND MEASUREMENTS OF INTERNAL ORGANS AND DRESSED WEIGHTS OF CARCASSES OF BARROWS[1]

MANUEL A. VELARDE[2]

The object of the study conducted in the Manila Slaughterhouse and the Malabon Slaughterhouse from January to September, 1946, was to determine the correlation between the weights and measurements of the internal organs and the weights of the dressed carcasses of barrows.

Review of literature

Sisson and Grossman[3] in 1938 reported in their studies the weights and measurements of internal organs of pigs, as follows:

Oesophagus. The oesophagus has a potential caliber in the adult of nearly 7 cm. at either end and 4.2 cm. in the middle.

Stomach. The stomach has an average capacity of about 5.7 to 8 liters.

Small intestine. The small intestine is 15 to 20 m. long.

Large intestine. The large intestine is about 4 to 4.5 m. long, the *caecum* (a part of the large intestine) about 8 to 10 cm. long.

Liver. The liver has an average weight in the adult of about 1.5 to 2 kilograms.

Spleen. The spleen is long and narrow and is extremely variable in size. In large animals it may reach a length of about 60 cm., a width of 8 to 10 cm., and a weight of 350 grams, or it may be only a little more than 35 cm. long and 7 cm. wide, and weigh 200 grams.

Trachea. The trachea is about 15 to 20 cm. long.

Kidneys. The weight of the kidney of an adult pig is about 200-250 grams. The ratio of their combined weights to that of the body is about 1: 150-200. The length in an adult of good size is about 12.5 cm. and the greatest width about 6-6.6 cm.

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[1]Experiment Station contribution No. 1461. Prepared in the Department of Animal Husbandry under the direction of Assistant Professor Mariano Mondoñedo.

[2]The writer wishes to acknowledge his indebtedness to Dr. P. P. Villa of the Manila Slaughterhouse, and his staff, and to Mr. Pedro Dionisio of the Malabon Slaughterhouse, for their assistance and cooperation.

[3]SISSON, S. AND J. GROSSMAN 1938. The anatomy of domestic animals. 3rd ed., p. 490, 499, 556, 557, 578. Philadelphia: W. B. Saunders Company.

Loreto,[4] in 1946, concluded in his studies on correlation of body measurements and dressed weights of pigs that body length, heart girth, and hind girth were all significantly correlated to the dressed weight.

Misner[5], in 1941, found in his study on correlation between measurements and weights of dairy cows that of all the different organ measurements, the heart girth was the most closely correlated with the actual weight of the animal.

MATERIALS AND METHODS

Materials

The materials used in the study were: 80 slaughtered grade barrows taken at random and varying in weight from 20 kgm. to 90 kgm.; a Toledo balance of 200-kilogram maximum weighing capacity and graduated to two-tenths of a kilogram, which was used to take the dressed weights; and a small "Family" balance with a maximum weighing capacity of 10 kilograms, graduated to 10 grams, and used for taking the weights of the internal organs.

Methods

Weights. The dressed carcasses were weighed, and the internal organs were measured soon after they had been detached from the carcass. They were separated according to their anatomical divisions.

Measurements. The measurements were taken as follows:

Stomach. The length of the stomach was measured from the dorsal to the ventral ends on the visceral surface. The width was measured along the greatest width from the greatest curvature to the lesser curvature.

Spleen. The length was measured from end to end, and the width was taken at the greatest width.

Kidney. The lengths of the left and right kidneys were taken from the anterior to the posterior ends, ventrally, and the widths, along their greatest widths.

Lungs. The lengths of the left and right lungs were measured along their greatest lengths from the anterior end of the apical lobe to the posterior ends of the diaphragmatic lobes. The measurements at their greatest widths were taken for the widths of the lungs.

Liver. The length was taken from the anterior to the posterior ends; the width at the widest part, after laying the organ flat on the table with the dorsal surface up.

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[4]Loreto, C. T. 1946. Preliminary correlation studies in the measurements of pigs and the weight of carcasses obtained therefrom. College of Agriculture Biweekly Bulletin 11 (7): 1-2.

[5]Misner, E. G. 1941. Measurements and weights of one hundred cows in Cornell dairy herd. Cornell Agric. Exper. Sta. Bull. 771: 11-12.

Urinary bladder. The bladder was measured empty, the length from the anterior to the posterior ends, and the width, at its greatest.

Heart. The length was measured from the base to the apex. The circumference was taken around the greatest width with a tape measure.

Trachea. The length was measured from the anterior end to the posterior where it bifurcates to the left and right lungs. The circumference was taken by means also of a tape measure.

Oesophagus. The length was measured from the anterior to the posterior ends, and the width in the middle.

Small intestine. The length was measured from the anterior to the posterior ends, and the width from the average of the measurements made on the duodenum, jujenum, and ilium.

Large intestine. The length was measured from the anterior end of the caecum to the rectum. The width was taken from the average of the measurements made on the caecum, on the large colon, on the small colon, and on the rectum.

RESULTS

Measurements of internal organs and dressed weights

The modal class range in the length of the oesophagus was between 29.4 and 30.2 centimeters, with a mean of $30.27 \mp .20$ centimeters. The variations in the length of this organ was relatively small, with a coefficient of variation of 5.946 ∓ 0.471 per cent.

The animals with very low dressed weights had only a slight increase in the length of the stomach. Those with dressed weights ranging from 24 to 47 kilograms had a marked increase. The modal class range in the length of this organ was between 20.7 and 21.6 centimeters, with a mean of $21.02 \mp .23$ centimeters.

The modal class range in the length of the small intestines was between 1563.6 and 1676 centimeters, with a mean of 1337.02 ∓ 0.30 centimeters. The variation in the length was more pronounced when the dressed weight of the animal was from 34 to 48 kilograms. The coefficient of variation was 1.101 ∓ 0.087.

The modal class range in the length of the large intestine was between 461.4 and 492.2 centimeters. The younger or older the animals, the less marked the increase in the length of this organ. The dressed weights of the animals that showed marked increase in the small intestine ranged from 34 to 47 kilograms; however, there were also cases when marked increase in the length was noted in some animals whose dressed weights ranged from 20 to 33 kilograms.

The length of the spleen was variable both in small and in large animals. The modal class range was between 31 and 32 centimeters, with a mean of 29.54 ∓ .32 centimeters.

The modal class range in the length of the liver was between 24 and 24.7 centimeters, with a mean of 24.42 ∓ .20 centimeters. The increase in the length of this organ became more marked as the dressed weight of the animal increased; the coefficient of variation was 6.55 ∓ 0.510 per cent, so that it can be used as an index of determining the dressed weights of carcasses.

The modal class range of the length of the right kindey was 8-8.4 centimeters, with a mean of 9.85 ∓ 0.31 centimeters, and the left kidney, 10.64 -11.15 centimeters, with a mean of 9.45 ∓ 0.31 centimeters. Every increase in the length of this organ was accompanied by a corresponding increase in the dressed weight. The left kidney had a higher coefficient of correlation than the right kidney; also it was bigger in size.

Little variations were noticed in the urinary bladder because it is relatively small; however, the range in dressed weight of carcasses that showed marked increase in the length of the bladder was 34-47 kilograms. The coefficient of variation was 26.50 ∓ 2.08, and the mean, 10.19 ∓ 0.30 centimeters.

Marked variation in the length of the heart was noted in animals that had dressed weights from 34 to 54 kilograms, the coefficient of variation being 20.42 ∓ 1.614 per cent, with a mean of 9.50 ∓ 0.23 centimeters. Animals with dressed weights below or above this range varied slightly in length.

The modal class range in the length of the right lung was 17-18 centimeters, with a mean of 17.90 ∓ 0.24 centimeters. The left lung had a modal class range in length of 17.5—18.9 centimeters, with a mean of 22.80 ∓ 0.28 centimeters. It was also noted that the left lung was consistently larger than the right lung; the mean difference being 4.90 ∓ 0.26 centimeters.

The modal class range in the length of the trachea was 24.4–25.1 centimeters, with a mean of 22.35 ∓ 0.34 centimeters. Marked variations in the length of the trachea were noted in animals that had dressed weights of 26–47 kilograms. The coefficient of variation was 13.86 ∓ 1.08 per cent. There were cases of animals with high dressed weights but with short tracheas, and vice versa.

The variations in the widths of some of the internal organs, like the oesophagus, spleen, kidneys, lungs, small intestine, and urinary bladder, were relatively small because these organs are narrow in comparison to their length. On the other hand, there were some animals with organs

like the stomach, liver, and large intestine that showed marked variations in the width. These organs may therefore be used as materials for determining the dressed weights of animals.

The modal class range of the stomach was 10–10.7 centimeters, with a mean of 12.75 ∓0.30 centimeters. The range in the dressed weights of the animals that had marked increase in the width was 27–61 kilograms. There were some big animals that had small stomachs, and some small animals with big stomachs.

Marked variation in the width of the large intestine was noted in animals with dressed weights of from 26 to 47 kilograms. The coefficient of variation was 66.06 ∓5.22 per cent and the modal class range, 4.0–4.22 centimeters. Of the four compartments of the large intestine, the caecum had the greatest degree of variability in increase.

It was noted that both the length and the width of the liver showed marked increase as the dressed weight increased. The modal class range in the width was 22.9 to 35.5 centimeters, with a mean of 22.35 ∓0.40 centimeters. The coefficient of variation was 9.61 ∓0.751 per cent. This organ may therefore be used as an index of determining the dressed weight.

The internal organs measured for their circumferences were the trachea and the heart. The measurement of the circumference of the trachea showed marked variation as the dressed weight increased. The coefficient of variation was 23.80 ∓0.375 per cent; its modal class range was 5.0–5.4 centimeters, with a mean of 5.88 ∓0.15 centimeters. The dressed weights of the animals that had marked increase in the circumference of the trachea ranged from 34 to 47 kilograms. Slight variations were noticed below and above this range.

It was noticed that generally, although not consistently, the bigger the animal, the smaller the heart circumference, and vice versa. This organ therefore, can not be depended upon as a means of determining the dressed weight.

Mean weights of internal organs and dressed weights. Marked increase in the weights were found in animals with dressed weights ranging from 27 to 68 kilograms. Less variation was noted in animals with dressed weights from 20 to 26 kilograms and from 69 to 90 kilograms.

Correlation between dressed weight and measurements of internal organs

Lengths of internal organs and dressed weight. Every increase in the length of the internal organ was accompanied by a corresponding increase in the dressed weight. The internal organs that had very high coefficients of correlation are the liver, small intestine, large intestine, left kidney, and trachea. Of these organs, the liver and the small intestine showed marked increase in the length as the dressed weight increased. These organs, therefore, may be used as means of determining the dressed weights.

Widths of internal organs and dressed weight. Every increase in the measurement of the width of the organ was accompanied by a corresponding increase in the dressed weight. The internal organs that had high coefficients of correlation are the stomach, liver, right kidney, and left lung. Of these organs, the stomach and the liver showed more marked increase in width as the dressed weights increased, probably because the increase in these organs is more easily measured. The liver and the stomach may therefore be used as means of determining the dressed weight.

Circumference of internal organs and dressed weight. The circumference of the trachea was found to be correlated to the dressed weight, whereas the circumference of the heart was not. The coefficient of correlation of the trachea was 0.44 and that of the heart, 0.15. The circumference of the trachea, therefore, may be used as an index of determining the dressed weight.

Weights of internal organs and dressed weight. The weights of internal organs correlated to dressed weights were all highly significant. The weight of the right kidney gave the highest coefficient of correlation, the value of r being 0.97, whereas the pancreas gave the lowest coefficient of correlation, r amounting to 0.53.

The writer found that the stomach, heart, spleen, liver, and lungs could be readily and completely separated from the points of attachments and easily measured. In the absence of a large weighing scale on the farm, a small balance may be used for weighing the internal organs in order to determine the dressed weight. The internal organs that are preferable to use are the liver and the spleen because they can be easily weighed after they have been severed from their attachments.

Application of the coefficient of correlation between the dressed weights and measurements of internal organs

By knowing the increase in the measurement or weight of internal organs, the dressed weight of pigs can be roughly estimated. This is made possible through the application of the regression formula $y=bx+c$.

For example: If the length of the spleen is 31 cm. the expected dressed weight can be found as follows, where y=the expected dressed weight, 0.50 =the increment for the length of the spleen, x=the actual measurement of the spleen, and c=a constant derived by multiplying the mean of the measurement by the increment and subtracting the resulting product from the mean dressed weight.

$$y=0.50 + 29.40$$
$$=0.50 \times 31 + 29.40$$
$$y=44.90$$

SUMMARY

1. The coefficients of correlation determined between the lengths, widths, and circumferences and weights of the internal organs and the dressed weights were all highly significant. The circumference of the heart did not show evidence of correlation to the dressed weight. Marked variations in the measurements of the lengths and widths of internal organs were noted in animals with dressed weights ranging from 26 to 47 kilograms. Likewise, the circumference of the trachea showed marked variability in animals with dressed weights ranging from 34 to 47 kilograms.

2. For practical purposes, the lengths of the liver, the small intestine, and the trachea, the widths of the stomach and the liver, the circumference of the trachea, and the weights of the liver and the spleen may be used in determining the dressed weights of animals because they are easily separated, measured, and weighed.

IPIL-IPIL (LEUCAENA GLAUCA LINN.) SEED MEAL IN RATIONS FOR GROWING CHICKS[1]

PRIMO I. PIZARRO

The scarcity and high price of animal protein feeds have made it necessary for local poultry raisers to depend mostly upon vegetable protein feeds to supplement their chicken rations. One of the materials that may be considered promising on account of its high protein content, availability, and abundance in many places of the country is the seed of ipil-ipil (*Leucaena glauca* Linn.). To determine the feeding value of ipil-ipil-seed meal as a supplement in rations for growing chicks a study was conducted from May, 1946, to February, 1947, in the Department of Animal Husbandry.

Review of literature

Villegas (1922), in his study on the toxicity of ipil-ipil, found that feeding horses with ipil-ipil in the form of leaves, seeds, and tender stem caused shedding of the mane and tail. Beaumont (1945) reported that, as a feed for all classes of livestock, ipil-ipil caused serious symptoms of illness and alopecia (loss of hair). Horses, swine, rabbits, and chickens were said to be adversely affected. The toxic effects and alopecia, however, have not been reported generally in cattle and other ruminants.

According to Beaumont, the toxic principle of ipil-ipil, which is present in the water-soluble fraction of the leaves and seeds, has been identified as mimosine ($C_8H_{10}O_4N_2$). This substance, which he claims to be an alpha-amino acid possessing phenolic properties, is present in the dry leaves and seeds of ipil-ipil to the extent of about 3 and 5 per cent, respectively.

Beaumont (1945) stated that ipil-ipil caused temporary sterility when fed as green roughage to brood sows.

MATERIALS AND PROCEDURE

The stock. Two hundred newly hatched Native chicks were used in this study. Three successive hatches were made and each hatch was randomized into two lots.

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[1]Experiment Station contribution No. 1462. Prepared in the Department of Animal Husbandry under the direction of Professor F. M. Fronda.

The ration. The rations used were composed of the following ingredients, all parts by weight:

FEEDS	LOT I	LOT II
Rice bran	56.25	56.25
Corn meal	18.75	18.75
Shrimp meal	20.00	———
Copra meal	5.00	5.00
Ipil-ipil-seed meal[a]	———	20.00

[a]The ipil-ipil-seed meal was obtained by grinding fine well-dried mature ipil-ipil seeds.

The amount of digestible nutrients contained in one kilogram of feed used is as follows[2]:

FEEDS	DIGESTIBLE PROTEIN	TOTAL DIGESTIBLE NUTRIENTS	NUTRITIVE RATIO
	kgm.	*kgm.*	
Rice bran	.075	.609	1: 7.1
Corn meal	.077	.842	1: 9.9
Shrimp meal	.450	.547	1: 0.2
Copra meal	.145	.785	1: 4.4
Ipil-ipil-seed meal	.248	.729	1: 1.9

The proximate chemical analysis of the feeds used is as follows:

FEEDS	MOISTURE	ASH	PROTEIN	TOTAL CARBOHYDRATES	FAT
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
Rice bran[a]	13.81	15.48	11.56	50.74	8.41
Corn meal[a]	13.88	2.61	8.90	70.14	4.41
Shrimp meal[a]	14.55	19.75	55.61	7.50	2.61
Copra meal[a]	12.83	7.26	17.50	56.64	5.77
Ipil-ipil[b]	13.68	6.27	66.38	12.08	15.27

[a]Analyzed by the Department of Agricultural Chemistry. Used by Santiago (1925) in his work on "Copra meal vs. dried shrimps as supplement to a basal ration containing corn and rice bran for growing barrows". The Philippine Agriculturist **15**: 207.

[b]Padilla, S. P., and F. A. Soliven. 1933. Chemical analysis for possible source of oils of forty-five species of oil-bearing seeds. The Philippine Agriculturist **12**: 408-415.

Weighing. A Ceneo balance with a maximum weighing capacity of 1000 grams and sensitive to one-tenth gram was used for weighing the chicks. The initial weights of the chicks were taken 48 hours after the eggs hatched, and weekly weights were obtained thereafter until the chicks were 12 weeks old. Weighing was done in the afternoon before the chicks were given their evening feed.

Feeding and care. During the first four weeks the chicks were placed at night in properly ventilated, fireless brooder-boxes to keep them warm. The chicks of both lots were housed in one of the breeding pens of the De-

[2]Unpublished data compiled by the Department of Animal Husbandry.

partment of Animal Husbandry. Improvised partitions were made to segregate the chicks in each lot. All-mash feeding was used. Water was provided the chicks at all times. The chicks in both lots had access to grassy yards. The chicks were subjected to the same management and care until they reached the weanling age of 12 weeks.

RESULTS AND DISCUSSION

Rate of growth. The average weekly gain in weight of the chicks was used as the criterion in determining the influence of the feed on their rate of growth.

It was observed that there was not much difference between lots I and II in the initial weight of the chicks in each trial. After the first three weeks of each trial, only slight differences were observed in the average weekly weights of the chicks in the two lots. From the fourth to the twelfth week, however, differences observed were marked. At the end of the experiment in the first trial, the birds in lot I had a final average weight of 528.6∓21.7 grams and those in lot II, only 277.3∓19.4 grams. In the second trial the chicks in lot I averaged 458.2∓4.9 grams and those in lot II, only 283.8∓4.4 grams. In the third trial the birds in lot I averaged 446.5∓24.1 grams and those in lot II, 270.0∓21.6 grams. These results indicate that the chicks in lot I were markedly and consistently heavier than those in lot II. In all the three trials the average weekly gains in weight of the birds in lot I were markedly better than those in lot II. When subjected to the "t" test, the differences in all the three trials were found to be highly significant, in favor of lot I. These figures tend to show that ipil-ipil-seed meal cannot be recommended as the principal source of protein supplement in rations for chicks.

Feed consumption. The comparison of feed consumption can best be made by comparing the average feed consumption of each bird. It was apparent that the birds in lot II did not relish the feed given them. When examined, the unconsumed portion of the feed given to this lot was largely composed of the hard coat of ipil-ipil seeds and rice bran. Apparently, the ipil-ipil-seed meal was not palatable to the birds. On the other hand, the birds in lot I readily consumed the feeds given them.

An attempt was made to induce the birds of lot II to eat more of the feed by giving it as wet mash. This method, however, failed to accomplish its object. The feed was left practically untouched, became discolored (reddish), and later turned rancid and produced a disagreeable odor. It was observed in the first trial that on the basis of the average feed consumption of each bird and the average weight of the birds at the age of 12 weeks,

7.3 kilograms of feed was needed to produce a gain in weight of 1 kilogram in lot I. For the same gain in weight in lot II, 9.9 kilograms of feed was needed. In the second trial, 8.2 kilograms of feed was needed to produce a kilogram gain in weight in lot I, and 8.4 kilograms in lot II; and in the third trial, 8.6 kilograms in lot I and 9.5 kilograms in lot II. These figures again show the superiority of lot I over lot II.

Mortality. In all the three trials, lot II had a higher mortality than lot I. The highest mortality in all the trials occurred during the first four weeks. The difference in the percentage of mortality between the two lots in the three trials was significantly in favor of lot II, as shown by the "t" test. Such significant difference may be attributed to the lower vitality of the birds in lot II as a result of the feed given them.

The rate of feathering. Although in the appearance of the primary feathers of the birds in both lots no marked difference was observed, there was in regard to the change of the down on the thigh, on the dorsal part of the neck, and along the sides of the body. By the fifth week the birds in lot I had these feathers already full-grown. The birds in lot II, however, did not have them fully developed even as late as the eighth week. Probably owing to the lowered vitality of the birds in lot II, the primary feathers were disproportionate to the size of their bodies on the twelfth week. Among the birds in lot II, the appearance of feathers on the back and along the keel to the vent was delayed even to as late as the third month (12 weeks). One particular bird in lot II in the first trial did not change its down during the experiment.

Other observations. With respect to health and vigor at the age of 12 weeks, the birds from lot I were apparently healthy and vigorous, whereas those of lot II appeared pale and rather thin, although they were fairly active. They appeared to be always hungry and vigorous grazers, continually scratching and exhibiting an eagerness to hunt for food. At the close of the experiment, the birds in lot II were very small for their age. The weights of the birds from lot I, however, favorably compared with those experimented on by Enerva (1924), who reported that Native chicks had an average weight of 426 grams at the age of 12 weeks.

There was a high mortality in the second and third trials. Such high percentage of mortality was due to roup, which affected the chicks in these trials. The disease was first observed among the birds of lot II. As previously mentioned, the chicks were separated by improvised wire partitions in the same poultry house, hence the possibility of contamination from one lot to the other. The higher mortality of the birds in lot II may be explained by their lowered vitality, which rendered them more susceptible to the disease.

SUMMARY

1. At the age of 12 weeks, the mean weights and the average weekly gain in weight of the birds in lot I (fed with the standard ration) were significantly greater than those of the birds in lot II (fed with standard ration in which the shrimp meal was replaced with ipil-ipil-seed meal).

2. Apparently ipil-ipil-seed meal was not relished by the chicks.

3. The chicks that were fed ipil-ipil-seed meal were pale, thin, and rather small for their age.

4. The poor vitality of the birds of lot II was probably one of the causes of the long delay in feathering and of the significantly high percentage of mortality in lot II.

5. In the light of the results obtained in this study, it appears that ipil-ipil-seed meal can not be recommended as the principal source of protein supplement in rations for chickens in spite of its high protein content.

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CHEMICAL BASIS FOR THE CONVERSION OF COCONUT OIL INTO HYDROCARBONS[1]

JULIAN BANZON
Of the Department of Agricultural Chemistry

The conversion of coconut oil, and of vegetable oils in general, into hydrocarbons may be postulated to take place according to the following chemical reactions:

$$\begin{array}{l} RCOOCH_2 \\ | \\ RCOOCH \\ | \\ RCOOCH_2 \end{array} + 3\ HOH \longrightarrow 3RCOOH + \begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array}$$

$$RCOOH \longrightarrow CO_2 + RH$$

The first reaction is well established and upon it is founded the process of hydrolytic splitting of fats and oils. The second reaction, a decarboxylation reaction, is not generally recognized and requires experimental verification or a chemical proof of its possibility. The proof requires calculation of free energy, ΔF°, at some fixed temperature.

DERIVATION OF A FREE ENERGY EQUATION FOR THE DECARBOXYLATION REACTION

The usual method of deriving a free energy equation (Lewis and Randall, 1923) is difficult in the present case because of the unavailability of data on ΔH_0 and ΔCp for the RCOOH. The "bond equations" of Bruins and Czarnecki (1941) afford a means of deriving the desired free energy equation.

Let the decarboxylation reaction be rewritten Cn H2n+1 COOH $\longrightarrow$ CO_2 + Cn H2n+2; therefore $\Delta F^\circ = \Delta F^\circ CO_2 + \Delta F^\circ cnH2n+2 - \Delta F^\circ$ CnH2n+1 COOH. (equation 1)

For the fatty acids, Cn H2n+1 COOH,

$$\Delta F^\circ = \Delta F^\circ C\text{-}COOH + (n\text{-}1)\ \Delta F^\circ C\text{-}C + (2n+1)\ \Delta F^\circ C\text{-}H$$

and for the hydrocarbons, Cn H2n+2,

$$\Delta F^\circ = (n\text{-}1)\ \Delta F^\circ C\text{-}C + (2n+2)\ \Delta F^\circ C\text{-}H.$$

Substituting these values in equation 1, we obtain

$$\Delta F^\circ = \Delta F^\circ CO_2 + [(n\text{-}1)\ \Delta F^\circ C\text{-}C + (2n+2)\ \Delta F^\circ C\text{-}H] - [(n\text{-}1)\ \Delta F^\circ C\text{-}C + (2n+1)\ \Delta F^\circ C\text{-}H + \Delta F^\circ C\text{-}COOH]$$

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[1]Experiment Station contribution No. 1463.

This simplifies to

$$\Delta F^\circ = \Delta F^\circ CO_2 + \Delta F^\circ C\text{-}H - \Delta F^\circ C\text{-}COOH \text{ (Eq. 2)}$$

But $\Delta F^\circ CO_2 = -94{,}110 + 0.60\ T \ln T - 0.00065\ T^2 - 0.0_6110T^3 - 3.74T$

$\Delta F^\circ C\text{-}H = -3{,}344 + 2.97T \ln T - 0.0023T^2 + 0.0_6188T^3 - 13.68T$

$\Delta F^\circ C\text{-}COOH = -89{,}867 + 6.29\ T \ln T - 0.00680T^2 - 0.0_656T^3 - 7.37T$

Substituting these values in equation 2 and simplifying,

$$\Delta F^\circ = -7{,}587 - 2.72\ T \ln T + 0.00385T^2 + 0.0_6638T^3 - 10.05T$$

This is the free energy equation finally derived for the decarboxylation reaction.

FREE ENERGY AT 573°K AND 1000°K

By substituting $T = 573°$ in the above free energy equation, $\Delta F°573 = -21{,}857$ calories. Such a large negative value for ΔF° shows that the decarboxylation reaction is a possible reaction at 573°K (300°C). At $T = 1000°K$ (727°C), $\Delta F°1000 = -31{,}930$ cals.

EQUILIBRIUM CONSTANTS AT 573°K AND 1000°K

The equilibrium constants for the decarboxylation reaction,

$$RCOOH\ (g) \longrightarrow CO_2(g) + RH\ (g)$$

may be calculated by means of the equation

$$\Delta F^\circ = -RT \ln K.$$

Substituting the values of ΔF° previously obtained and the corresponding values of T and R = 2 cals, then

$\log K_{573} = 8.291$, $K573 = 1.95 \times 10^8$

$\log K_{1000} = 6.941$, $K_{1000} = 8.73 \times 10^6$

DIRECT CONVERSION OF GLYCERIDES TO HYDROCARBONS

The direct conversion of glycerides into hydrocarbons may be postulated to take place according to the following reaction:

$$\begin{matrix} RCOOCH_2 \\ | \\ RCOOCH \\ | \\ RCOOCH_2 \end{matrix} + 3HOH \longrightarrow 3RH + 3CO_2 + \begin{matrix} CH_2 \\ \| \\ CH \\ | \\ CHO \end{matrix}$$

Direct experimental proof for the above reaction was given by results reported in an earlier paper (Banzon, 1937). In those experiments, coconut

oil, upon pyrolytic treatment, gave carbon dioxide, acrolein, ketones, saturated hydrocarbons, and unsaturated hydrocarbons.

The reaction postulated above can account for the carbon dioxide, the saturated hydrocarbons and the acrolein. The unsaturated hydrocarbons may be accounted for by the pyrolytic decomposition of some of the high molecular weight saturated hydrocarbons initially produced:

$$\begin{matrix} C_{11}H_{23}COOCH_2 \\ | \\ C_{11}H_{23}COOCH \\ | \\ C_{11}H_{23}COOCH_2 \end{matrix} + 3HOH \longrightarrow 3C_{11}H_{24} + 3\,CO_2 + \begin{matrix} CH_2 \\ \| \\ CH \\ | \\ CHO \end{matrix}$$

$$C_{11}H_{24} \longrightarrow \begin{matrix} CH_2 \\ \| \\ CH_2 \end{matrix} + C_9H_{20}$$

$$C_9H_{20} \longrightarrow \begin{matrix} CH_2 \\ \| \\ CH_2 \end{matrix} + C_7H_{16}$$

The ketones are accounted for by a parasitic reaction taking place simultaneously with the main reaction:

$$2\left[\begin{matrix} RCOOCH_2 \\ | \\ RCOOCH \\ | \\ RCOOCH_2 \end{matrix}\right] \longrightarrow 3\left[\begin{matrix} R \\ > CO \\ R \end{matrix}\right] + 2\left[\begin{matrix} CH_2 \\ \| \\ CH \\ | \\ CHO \end{matrix}\right] + 3CO_2 + H_2O$$

The large amounts of ketones obtained in previous experiments (Banzon, 1937, Holleman and Koolhaas, 1939) are explainable by this reaction. The use of iron powder or ferric oxide as a catalyst favors the formation of ketones in the pyrolytic decomposition of coconut oil (Banzon, 1937). It should be pointed out here that, according to these postulated chemical reactions, the formation of hydrocarbons from coconut oil is favored by the presence of water, which takes part in the reaction. The absence of water will favor the formation of ketones.

SUMMARY

1. An investigation has been made on the possibility of converting coconut oil into hydrocarbons according to the reactions,

$$(RCOO)_3\,C_3\,H_5 + 3\,HOH \longrightarrow 3\,RCOOH + C_3\,H_5\,(OH)_3, \text{ and}$$
$$RCOOH \longrightarrow CO_2 + RH$$

2. For the latter reaction, a free energy equation has been derived, using the approximate "bond equations" of Bruins and Czarnecki. The

calculations indicate that the decarboxylation reaction is a possible reaction at 300°C.

3. For the direct conversion of glycerides into hydrocarbons by pyrolysis, a chemical reaction has been formulated, with experimental evidences for support.

4. A chemical reaction has also been formulated to account for the large amounts of ketones experimentally obtained under certain conditions of pyrolytic decomposition.

5. The special rôle of water in controlling reaction products is demonstrated.

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COLLEGE AND ALUMNI NOTES

The war in the Philippines broke out on December 8, 1941. In order to permit the students to go home while transportation was still available, the Christmas recess of the College was advanced to December 13. The College experienced enemy bombing in the afternoon on Christmas Day of 1941, when three Japanese bombers attacked the Campus. One of the bombs hit the Molawin Hall and destroyed it completely. There was one casualty, a man from Manila who evacuated to the College, believing that the place was safer than the city.

The College did not reopen until January 23, 1942, when the Philippine Executive Commission was established by the Japanese. At that time it was generally believed that the war would not last long. The College remained open throughout the war years. Owing to reduced faculty, lack of materials and supplies, widespread feeling of uncertainty and of fear, instruction and scholarship were seriously affected and research work was practically stopped. The influx of scientific literature stopped, and the publication of THE PHILIPPINE AGRICULTURIST ceased after the appearance of volume 30, No. 7, December, 1941.

In September, 1942, the same month when the permit to open the College was finally issued, a recuperative camp for released Filipino war prisoners was established on the Campus. Then, in May, 1943, the greater part of the College was transformed into an internment camp for Allied nationals.

From the beginning, the Japanese had no confidence in the faculty of the College. Their principal reason was that the ranking members were holders of degrees from American universities. After the middle of 1943, the organization in the College of a guerrilla unit, the "Home Guard," came to the knowledge of the Japanese. As a consequence, all male members of the faculty and of the student body and the laborers were concentrated from August 19 to September 1, and then until September 10, they were subjected to rejuvenation training which consisted of salute to the Imperial Palace followed by calisthenics and military training in the morning, forced labor in the afternoon, and singing Japanese patriotic songs until nine o'clock in the evening. Dean L. B. Uichanco, Dr. Pedro A. David, and the members of the Home Guard were confined in the military garrison in Santa Cruz, Laguna, and there subjected to more rigid spiritual rejuvenation. They were released towards the end of September, except Dean Uichanco and Dr. David, who were sentenced to death on charges of (1) hiding

Americans, (2) hiding firearms, and (3) maintaining guerrillas. Only the intercession of high Filipino officials in the occupation government saved the two from execution. Dean Uichanco was confined in the Japanese military hospital for treatment of a dislocated shoulder which he suffered when he was subjected to the third degree. He was finally released about the middle of November, 1943. Although Dean Uichanco and Dr. David were pardoned, they were dismissed from service by the Commissioner of Education, effective September 30, 1943. President B. M. Gonzalez had to resign, too. When the College was authorized to reopen on September 23, 1943, Dr. Francisco O. Santos was designated dean.

On October 1, 1943, the Japanese army and the chief of staff, General Oba, bivouacked on the Campus. They occupied most of the faculty houses and laboratory buildings. Almost daily, Filipinos were brought to the garrison, tortured, and finally disposed of with bayonet thrusts.

In 1944, the Japanese knew that the return of General McArthur's forces was expected anytime. The Japanese were often heard to say to Filipinos, "Your friends are coming but you will not see them when they arrive." Los Baños and its vicinity were raided by American planes for the first time in the morning of December 31, 1944, then a week later, and finally more often and at no definite interval. As the visits by American planes came more often, it became too much of a hazard to go out. Some of the members of the faculty and students could not attend their classes because they had to report to the guerrilla units to which they belonged.

Early in the morning of February 23, 1945, guerrillas composed of the College boys and of other outside units surrounded the internment camp and held it until the Eleventh Airborne paratroopers and the amphibious tanks of the First Cavalry Division of the United States Armed Forces arrived and liberated the Allied internees. In retaliation, the Japanese, on the night of February 26, burned the residential and laboratory buildings in the College, raped women, and massacred men, women, and children, including infants in their mothers' arms. The buildings which were totally destroyed by fire were:

1. Soils
2. Plant Pathology
3. Biochemistry
4. Rural High School Main Building
5. Rural High School Farm Shop
6. Rural High School Tool Bodega
7. Maquiling School
8. Agricultural Chemistry
9. Sugar Mill
10. English
11. Old College Building
12. Hawaiian Sugar Planters' Insectary
13. Old Armory
14. Poultry
15. Seed Laboratory
16. Plant Breeding
17. Plant Propagation Nursery
18. Floriculture
19. Infirmary
20. Animal Husbandry Main Building
21. Stables
22. Ice Plant
23. Animal Husbandry Work Shop.

The buildings which were partially damaged were:

1. Agricultural Education
2. Entomology
3. Administration Building
4. Agricultural Botany
5. Agronomy Main Building
6. Power House
7. Baker Hall
8. Hog House
9. Unfinished Dairy Building
10. Farm Management
11. Seniors' Social Garden
12. Chicken Houses

Agricultural Engineering was the only building not damaged.

Of the residences on the Campus, four student dormitories, nine student bungalows, all houses of self-supporting students on Copeland Heights, and twenty-two houses of members of the faculty and employees were totally destroyed. Three houses of faculty members were partially damaged and two were not.

The two concrete bridges across the Molawin Creek were dynamited. One was so badly damaged that it is not passable to vehicles. The roads were also damaged.

With the burning of most of the buildings, the College lost its collection of agricultural crops, botanical specimens, which consisted of some 30,000 accessions, the insect collection which ranked as one of the best in the Far East, the collection of plant diseases, including the extensive herbarium which had been donated by the late Dean Charles Fuller Baker, the collection of fish, reptiles, amphibians, birds, mammals, and other animals, and the collection of soils. Nearly all scientific equipment were either burned or looted. Except for 180 books and an assortment of pamphlets, the College Library lost all of the 20,000 volumes, 6,000 pamphlets, 1,400 thesis manuscripts, 500 scientific journals and serial publications, the entire stock of volumes 28, 29, and 30 (Nos. 1–7) of THE PHILIPPINE AGRICULTURIST, and a well-equipped bindery. In addition, the College lost records of the administration office, student records, and records of technical departments, which include research data, unpublished manuscripts, and lecture and laboratory notes.

On March 24, 1945, Los Baños was liberated from the Japanese. The College soon followed. On March 28, Dean Uichanco was recalled by the Secretary of Instruction, who held interim jurisdiction over the University because at that time there was as yet neither University President nor Board of Regents. The Dean was asked to begin work at salvaging and taking initial steps at reestablishing the College of Agriculture and the School of Forestry. On April 4, Dean Uichanco, accompanied by Dr. G. O. Ocfemia, visited the College Campus and the School of Forestry. A few days later the Dean appointed the first salvage staff.

On April 28, while salvage work was under way, the College was occupied by the Sixth U. S. Army as a recreation camp. Several big units of the XIV Corps established themselves on the Campus.

On July 1, 1945, the Board of Regents was appointed and this in turn recalled President Gonzalez to his old post. After a conference with the President on July 3, Dean Uichanco was instructed to prepare a budget for sixty per cent of the prewar personnel. The budget was submitted to the President in the morning of July 13, and it was approved by the Board of Regents in the afternoon of the same day. On July 19 Dean Uichanco called the first faculty meeting with an attendance of 19 members. With but three buildings available for class rooms and laboratories of the different departments and the Rural High School, the first-semester classes were started on July 25, making the College the first unit of the University to reopen to its students. The enrollment was 119, of whom 33 freshmen were new. In the Rural High School the enrollment was 219, of whom 75 were new. There were 79 girls in the Rural High School. In the second semester, which began on December 10, the enrollment in the College increased to 158, of whom 68 were new. In the Rural High School the enrollment went down to 182 because of the graduation of 19 out of 22 seniors. From the initial 29 faculty members in July, 1945, the teaching staff grew at the end of the academic year to 42 members, which was the maximum allowed by the order restricting the personnel to 60 per cent of the 1941 personnel, distributed as follows:

Agricultural Botany	3
Agricultural Chemistry	5
Agricultural Economics	1
Agricultural Education	7
Agricultural Engineering	4
Agronomy	5
Animal Husbandry, including President Gonzalez as professor	9
English	1
Entomology	3
Plant Pathology	2
Soils	2
Physical Education	1
Total	42

As the U. S. Army left the Campus, the College was able to expand to the other buildings. Agronomy moved to the Agronomy Main building on August 20; Agricultural Education, Agricultural Economics, English, and the Rural High School transferred to the Agricultural Education building

on October 9. Agricultural Chemistry, Entomology, Plant Pathology, Soils, and the Infirmary were able to transfer to the Entomology building after restoring the partitions and repairing the damaged walls, doors, and windows of the building.

From 1942 to 1946, 151 students graduated with the degree of Bachelor of Science in Agriculture as follows: 1942—53 students; 1943—20; 1944—27 with 1 M.S. (in plant breeding); 1945—29 with 1 M.S. (in plant pathology), and 1946—22. Seven in the class of 1942, and one in the class of 1945, who were killed in line of duty, were graduated posthumously.

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